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FINAL DRAFT
Bay Area Regional Desalination Project Greenhouse Gas Analysis

11 January 2013

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Bay Area Regional Desalination Project

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Acronyms and Abbreviations

AB 32	California Assembly Bill 32, the Global Warming Solutions Act
AF	acre-foot or acre-feet
AFY	acre-feet per year
BAAQMD	Bay Area Air Quality Management District
BARDP	Bay Area Regional Brackish Water Desalination Project
BCDC	Bay Coastal Development Commission
BWRO	brackish water reverse osmosis
CARB	California Air Resources Board
CCA	community choice aggregation
CCC	California Coastal Commission
CCD	closed circuit desalination
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
CIP	clean-in-place
CO_2	carbon dioxide
CPUC	California Public Utilities Commission
CVP	Central Valley Project
Delta	Sacramento-San Joaquin River Delta
EBMUD	East Bay Municipal Water District
EIR	Environmental Impact Report
Energy Plan	Energy Minimization and Greenhouse Gas Reduction Plan
EOP	Energy Optimization Program
ERD	energy recovery device
FOG	fats, oils and grease
FTE	full-time equivalent
FWTE	food waste to energy
GHG	greenhouse gas
HEW	high-efficiency clothes washers
IRWD	Irvine Ranch Water District
JPA	joint powers authority
kgal	thousand gallons
kWh	kilowatt-hours
LEED	Leadership in Energy and Environmental Design

MF	microfiltration
mgd	million gallons per day
mg/L	milligram per liter
MID	Modesto Irrigation District
MT CO_2e	metric tons of equivalent carbon emissions
MW	megawatt
NSF	National Sanitation Foundation
Partners	CCWD, EBMUD, SCVWD, SFPUC and Zone 7
PG&E	Pacific Gas and Electric
PPA	power purchase agreement
PV	photovoltaic
REC	renewable energy credit
RO	reverse osmosis
SCADA	Supervisory Control and Data Acquisition
SCVWD	Santa Clara Valley Water District
$scwd^2$	City of Santa Cruz Water Department & Soquel Creek Water District
SFPUC	San Francisco Public Utilities Commission
SJVAPCD	San Joaquin Valley Air Pollution Control District
SLC	State Lands Commission
SMUD	Sacramento Municipal Utility District
SWH	solar water heater
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWRO	seawater reverse osmosis
TDS	total dissolved solids
TOS	threshold of significance
TOU	time-of-use
US EPA	United States Environmental Protection Agency
UWMP	urban water management plan
VFD	variable frequency drive
WAPA	Western Area Power Administration
WTP	water treatment plant
WWTP	wastewater treatment plant
Zone 7	Zone 7 Water Agency

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Section 1: Introduction

1.1 Project Background

Northern California is susceptible to prolonged periods of drought that can severely impact water quality and reliability, as well as the local economy and quality of life. Five water agencies – Contra Costa Water District (CCWD), East Bay Municipal Utility District (EBMUD), Santa Clara Valley Water District (SCVWD), San Francisco Public Utilities Commission (SFPUC), and Zone 7 Water Agency (Zone 7), referred to as the Partners – are evaluating the Bay Area Regional Desalination Project (BARDP) to improve long-term water supply reliability.

The BARDP would divert brackish surface water from the Sacramento-San Joaquin River Delta (Delta) through an existing intake at the CCWD Mallard Slough Pump Station to provide between 10 and 50 million gallons per day (mgd) of local, reliable, drought-proof water to the Partners. For planning purposes, the analyses contained in this report are based on an estimated production capacity of 20 mgd to be shared among the Partners. This brackish surface water supply would add to the Partners' water supply portfolios and improve long-term water supply reliability for the San Francisco Bay Area.

The Partners' current water supply portfolios include some or all of the following general components:

- Surface water from local or regional storage reservoirs
- Local groundwater (including existing brackish groundwater desalination)
- Recycled water
- Imported water from the State Water Project and the Central Valley Project
- Imported water from the Tuolumne and Mokelumne River watersheds
- Imported water from other water agencies
- Nonpotable supplies such as rainwater, stormwater, greywater, blackwater, and foundation drainage

Since 2003, the Partners have conducted feasibility studies evaluating various sites and piloted brackish surface water desalination technologies at the Mallard Slough site. They are now conducting a Site-Specific Analysis based on the Mallard Slough site, which includes this Greenhouse Gas (GHG) Analysis as one of the main tasks. The analysis is scheduled to be completed in 2013. For more information about the BARDP, including previous reports and presentations, see: http://www.regionaldesal.com/.

While the BARDP would provide water supply reliability by augmenting water supplies, the Partners are continuing to rigorously implement water conservation programs as a primary means of improving water supply reliability from the demand management side of the equation. A brief description of the Partners' conservation programs is presented below (more detailed descriptions of these conservation programs are available on each utility's website):

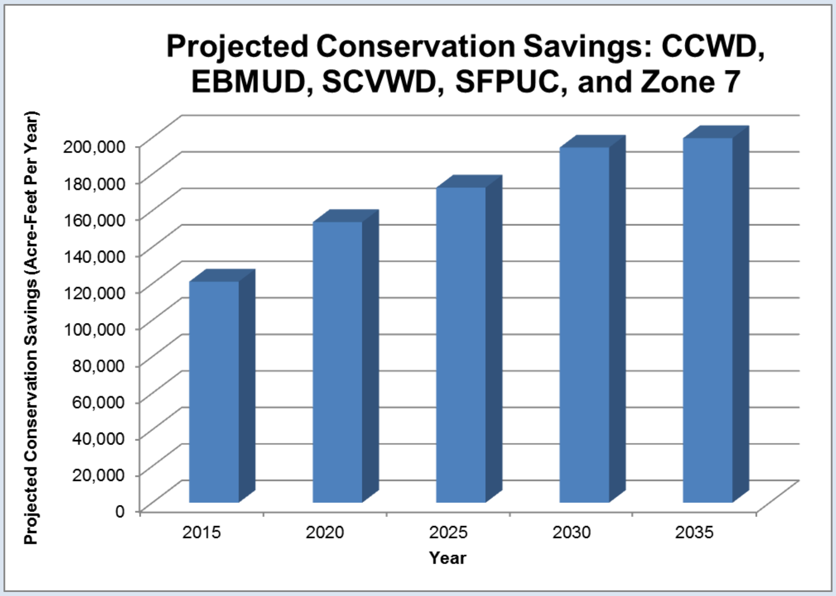
- *CCWD*: CCWD has successfully developed, implemented, and maintained an effective water conservation program since 1988. Conservation has significantly lowered current water use levels and will reduce the need for future supplies. For example, CCWD serves less water today than during the early 1990s, despite a 40% increase in population. CCWD works closely with its customers to encourage water conservation, eliminate water waste, and generally adapt to the possibility of drier years ahead. CCWD is also partnering with local industries in the service area to identify and implement projects to accomplish a combined objective of water, energy, and wastewater reduction for sustainability. The benefits are cost and waste reduction, greenhouse gas emission reduction, and water savings. CCWD will continue to look for new, cost-effective technologies, refine and improve existing conservation programs, and evaluate regional opportunities to implement conservation projects, with total water savings resulting from conservation expected to equal 21,000 acre-feet per year by 2035.

- *EBMUD:* Since the 1970s, demand management has been an important part of EBMUD's long-range integrated water resource planning process. As part of its Water Supply Management Program(s), EBMUD has identified a water conservation savings goal totaling 62 mgd for the years 1995 through 2040. EBMUD adopted its first Water Conservation Master Plan (WCMP) in 1994 and updated it in 2011. Over the fifteen-year period between 1995 and 2010, EBMUD has invested more than $70 million and its customers have saved an estimated additional 26 mgd through conservation practices. Over the 30-year period between 2010 and 2040, EBMUD and its customers are planning to save an estimated additional 36 MGD through conservation practices at an estimated cost of more than $100 million.

- *SCVWD*: Water conservation is an essential component in meeting SCVWD's mission of providing a reliable water supply to current and future generations. Because of the investments SCVWD has made in water conservation since the late 1980s, water use in Santa Clara County has remained relatively flat despite a 25% increase in population over the same time period. Through implementation of its long-term water conservation program, which includes a variety of residential, business and agricultural programs, SCVWD was able to achieve 54,200 acre feet of water savings in Fiscal Year 2011/2012. Water conservation will continue to be a key part of SCVWD's core business in the future: by the year 2030, water conservation efforts will account for approximately 20 percent of the total water supply.

- *SFPUC*: Conservation is an important part of the SFPUC's efforts to manage, diversify and protect our water supply from possible disruption caused by drought, climate change and natural disaster. In addition to implementing water conservation codes and measures, SFPUC's conservation program provides a wide range of customer incentives, services, school education, and assistance to promote the efficient use of water among its retail water customers. While San Francisco's estimated residential per capita water use continues to remain one of the lowest in the state at approximately 50 gallons per person per day, the SFPUC is also taking further steps to ensure water supply reliability by reducing dependence on imported water through increased conservation and use of local supplies such as groundwater, recycled water, and other non-potable supplies. Since 1965, despite population growth, San Francisco's total retail demand has declined by over one-third. Between 2005 and 2011, conservation activities are estimated to have saved 1.8 mgd, keeping the SFPUC on track to meet the goal of 4 mgd of demand reduction by 2018. Looking ahead, retail water demand models project a decline in per capita use through 2020 based on estimated water savings from continued conservation.

- *Zone 7 Water Agency:* In 2008, Zone 7 became a signatory to the Memorandum of Understanding Regarding Urban Water Conservation in California and has since remained a member of the California Urban Water Conservation Council. As a member, Zone 7 is committed to make a good-faith effort to implement the Best Management Practices (BMPs) in urban water demand management that are relevant to wholesale water agencies. Zone 7's conservation program includes: large landscape survey audits, conservation education and training, turf-conversion, weather-based irrigation controllers, rebates for water-efficient washers and toilets, and distribution of water-saving devices. Furthermore, Zone 7 supports its retailers (City of Livermore, City of Pleasanton, Dublin San Ramon Services District, and California Water Service Company) with implementation of other BMPs at the retailer level. Together with its retailers, Zone 7 is committed to meeting the requirements of the Water Conservation Act of 2009.



By 2035, conservation savings by the BARDP Partners are projected to be equivalent to the potable water needs of ***400,000 households or about 1.2 million people****.*

1.2 Purpose of the GHG Analysis

The energy requirement of desalination is among the key considerations in the evaluation of the BARDP. In line with their environmental stewardship principles, the Partners are committed to minimizing the energy use and carbon footprint of the proposed BARDP. An Energy Minimization and Greenhouse Gas (GHG) Reduction Plan (Energy Plan) is an important tool to ensure that advanced and energy-efficient desalination technologies and approaches are identified and incorporated into the proposed BARDP design.

This GHG Analysis is the first step in the process of building a comprehensive Energy Plan for the project and provides the following information and benefits to the BARDP:

- Provides a summary of current GHG regulations and guidelines
- Estimates the BARDP desalination facility unit energy consumption, and identifies opportunities to reduce energy consumption and lower operating costs
- Calculates 30-year projections for desalination supply energy use and associated indirect GHG emissions, and quantifies potential avoided water supply emissions
- Investigates project opportunities to reduce or offset GHG emissions
- Develops information to support California Environmental Quality Act (CEQA) analysis
- Provides information to support public outreach on this important issue
- Builds a solid foundation for more detailed analysis in later project phases

The Energy Plan ultimately will serve multiple purposes for the BARDP evaluation. Specifically, the Energy Plan informs the Environmental Impact Report (EIR) on the technical aspects of the energy and GHG impact of the BARDP, guides agency policy makers in evaluating and selecting future GHG reduction projects and programs, and serves as the formal document of record to permitting agencies requiring an energy and GHG reduction plan.

Section 2: GHG Regulations and Guidelines

The regulatory and legislative guidelines for brackish and seawater desalination energy are complex and varied. Agencies pursuing desalination must rely on direction from the CEQA, legislative guidelines, legal precedence, and regulatory agencies to define energy minimization and GHG reduction requirements and other potential measures. This section describes current energy minimization and GHG reduction guidelines regarding brackish and seawater desalination. These guidelines frame the study and management of the energy consumption and associated GHG emissions of the BARDP.

2.1 California Environmental Quality Act (CEQA)

The CEQA requires projects to investigate and report on potential environmental impacts. If implemented, the BARDP will be required to complete an Environmental Impact Report (EIR) that must include an estimation and evaluation of the significance of GHG emissions associated with the project and determine whether the project would:

- Generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment, or
- Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of GHGs.

Overall, the evaluation of GHG emissions in an EIR must determine whether a project's incremental contribution to global climate change would be cumulatively considerable. If so, the impact would be considered significant under CEQA.

Agencies typically rely on evaluating the cumulative environmental impact of a particular constituent of a project by comparing the magnitude of that constituent to a threshold of significance (TOS). The recently amended CEQA guidelines do not identify a TOS for project-related GHGs; rather, it requires the lead agency to determine a TOS for the project and to consider whether project emissions exceed that TOS. Lead agencies can develop their own thresholds or rely on thresholds that have previously been adopted or recommended by other agencies or experts. (AEP, 2012).

Currently, adopted thresholds vary based on agency and region. The Bay Area Air Quality Management District (BAAQMD) has a threshold of 10,000 metric tons of equivalent carbon emissions (MT CO_2e) per year for stationary sources or 1,100 MT CO_2e for non-stationary sources. The San Joaquin Valley Air Pollution Control District (SJVAPCD) guidance states that a project is “less than significant” if Best Performance Standards are implemented, or otherwise a project must demonstrate a 29 percent reduction in GHG emissions from business-as-usual, consistent with emission reduction targets established in the California Assembly Bill 32 (AB 32), the Global Warming Solutions Act (discussed in Section 2.2).

A TOS for the BARDP will be investigated and established as part of the future EIR process for the project.

2.2 California Global Warming Solutions Act (AB 32)

Assembly Bill (AB) 32, which was signed into law in 2006, sets reduction goals for direct emitters of GHGs and requires mandatory reporting only for facilities with direct emissions greater than 25,000 MT CO_2e, facilities with one megawatt (MW) or more of cogeneration, and other specific facilities. Because the BARDP Desalination Facility would not generate direct GHG emissions, BARDP does not have any AB 32 compliance requirements.

One of the goals of AB 32 is to reduce statewide GHG emissions to 1990 levels by the year 2020. Although there is no regulatory requirement to implement this type of goal for BARDP, this level of GHG reduction could be pursued as a voluntary action by the Partners.

2.3 Resource Agencies and Permitting Requirements

The Partners will be required to apply for permits for BARDP from various regulatory and resource agencies. Regulatory and resource agencies are starting to require the evaluation and reduction of energy consumption and GHG emissions as part of the permitting process. Also, the California Coastal Commission (CCC) and the State Water Resources Control Board (SWRCB) are in the process of developing guidelines for desalination projects.

The CCC has stated in both the Coastal Act (Section 30253) and a guidance document entitled “Seawater Desalination and the California Coastal Act” (CCC, 2044) that “energy consumption of new development be minimized.” Neither document specifically discusses GHG emission reductions.

The Regional Water Quality Control Board (RWQCB), and possibly the State Lands Commission (SLC), will have permitting authority over the wastewater outfall that BARDP would use for brine discharge. While the RWQCB and SLC do not have any specific jurisdiction over energy minimization and GHG reduction for new development projects, they rely on the CEQA evaluation to evaluate the significance of the energy and GHG impacts.

Regardless of their specific jurisdictions, regulating agencies have included energy minimization and GHG reduction in their permit requirements for other proposed California desalination projects, including the Carlsbad and Huntington Beach projects. Both projects adopted a No Net Increase (also known as a Net Carbon Neutral) GHG reduction approach as part of the permitting process. The No Net Increase goal is described in Section 5.

2.4 Partner Agency Goals

In addition to CEQA and regulating agency requirements and guidelines, the Partners may have individual agency policies or programs that could guide GHG reduction objectives for that agency. Specific agencies could voluntarily set a GHG reduction goal greater than required by CEQA for BARDP.

Potential GHG reduction goals are discussed further in Section 5.

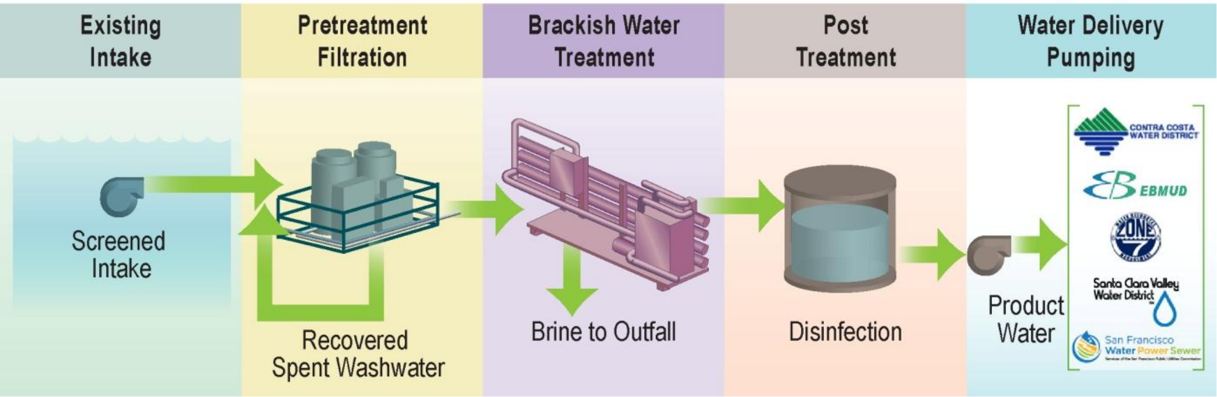
Section 3: Desalinated Water Supply Energy Use

All potable water supplies require some energy to collect, treat and distribute the water to customers. Different water supplies require different amounts of energy per unit volume of water delivered, depending on the water source, the amount of treatment required, and the distance and elevation at the point of delivery. This unit energy factor is typically described in units of kilowatt-hours per thousand gallons of water (kWh/kgal) or kilowatt-hours per acre-foot of water (kWh/AF). This section calculates the unit energy factor and the estimated energy use for the proposed BARDP desalinated water supply.

3.1 Desalination Process

The BARDP desalination process would withdraw brackish surface water from the Delta through an existing intake at the CCWD Mallard Slough Pump Station to produce up to 20 mgd of potable water. At the desalination facility, the water is first filtered to remove suspended solids (“dirt” particles) and bacteria from the water. This process is similar to filtration treatment at the Partners’ surface water treatment plants (WTP). The filtered brackish water is pumped at moderate pressure through reverse osmosis (RO) membranes that remove dissolved solids (salts) to produce both desalinated water and water with concentrated salts (brine). The fresh water is disinfected and treated to minimize corrosion (also similar to typical Partner WTPs). Figure 3-1 shows the general process steps for the BARDP desalination treatment process.

Figure 3-1 BARDP Desalination Process



The treated product water then would be pumped into either or both: 1) CCWD’s Multi-Purpose Pipeline (MPP) for delivery to CCWD customers; 2) EBMUD’s Mokelumne Aqueduct #3 for delivery to EBMUD’s water treatment plants and subsequent delivery to other Partners. The desalinated water could also be indirectly stored via exchange in CCWD’s Los Vaqueros Reservoir for later delivery to partners. Figure 3-2 shows the general delivery alternatives for the BARDP desalinated water supply.

Specific brackish water desalination treatment processes and technologies were evaluated and are described in the BARDP Pilot Plant Engineering Report (2010 Pilot Report) (MWH, 2010). The work described in this GHG Analysis builds off of the treatment approach and conceptual design from the 2010 Pilot Report. The recommended brackish water treatment process for the BARDP desalination facility is a two-stage brackish RO treatment train that includes:

- Existing passive wedgewire screen intake and raw water pumping system
- Ultrafiltration (UF) pretreatment with recovery and recycling of the spent washwater
- Two-stage brackish water RO system where the concentrate from the first RO stage is treated through a second seawater RO system to improve overall system recovery
- Disinfection and corrosion control system with a product water tank to provide system operational flexibility
- Distribution pump station to deliver water into CCWD’s MPP or EBMUD’s Mokelumne Aqueduct #3

3.2 Desalinated Water Supply Energy Components

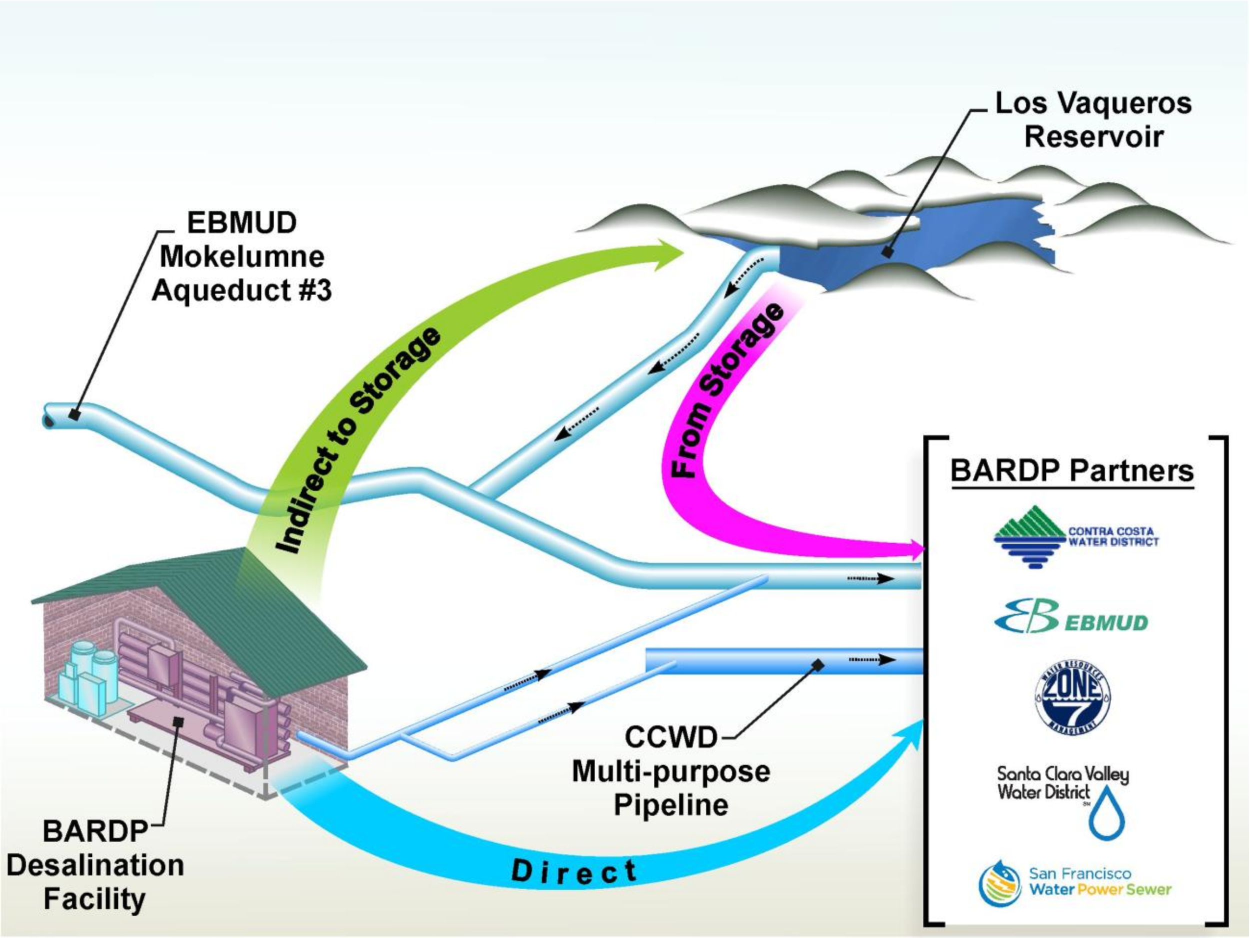
The anticipated use of the BARDP desalinated water supply would occur in three ways:

- **Direct Delivery** – BARDP Desalination Facility produces water that is directly distributed to Partners via CCWD’s MPP or EBMUD’s Mokelumne Aqueduct #3.
- **Indirect To Storage –** BARDP Desalination Facility produces water that is transferred via exchange with CCWD to storage in Los Vaqueros Reservoir for future use
- **From Storage –** Previously “indirectly stored” desalinated water is withdrawn from Los Vaqueros Reservoir and distributed to Partners

Figure 3-2 shows the general delivery alternatives for the BARDP desalinated water supply. Based on the different modes of water delivery, the major elements of energy use for the proposed BARDP desalinated water supply include:

- Energy use of the BARDP Desalination Facility to produce potable water
- Energy to deliver the product water to the Partners, and provide additional treatment, if required
- Energy to indirectly store water in Los Vaqueros Reservoir

Figure 3-2 BARDP Desalinated Water Supply Uses



While the energy use of the BARDP Desalination Facility depends on the salinity and temperature of the source water, the energy per unit volume of produced water (in kWh/AF) is the same for all of the Partners. The energy to store water in Los Vaqueros Reservoir also is the same for all of the Partners. However, the energy for delivery of the desalinated water supply to the individual Partner distribution systems is different for the five Partners. The details of the energy use for the three energy components of the desalination supply are provided in the following sections.

3.2.1 Desalinated Water Facility Water Production Energy Use

The primary energy requirements for the proposed BARDP Desalination Facility water production include:

- Pumping energy to lift source water from Mallard Slough into the facility intake
- Energy for the UF pretreatment processes

- Energy for the brackish water RO desalination process (brackish and seawater membranes) including the energy recovery devices

- Energy for the disinfection and corrosion reduction processes

- Energy for the conveyance of brine solution

- Miscellaneous energy for lighting, controls, building loads, etc.

To estimate the amount of energy used by the proposed BARDP Desalination Facility processes, an equipment list was developed to include the major process components that use energy based on the conceptual design criteria and information presented in the 2010 Pilot Report. A detailed process flow schematic of the BARDP Desalination Facility two-stage brackish RO treatment train is included in Appendix A.

The conceptual design process equipment list was incorporated into an energy calculation spreadsheet tool that calculates the estimated total energy use of the proposed treatment facility. The unit energy for the overall process and sub-components also is calculated. Table 3-1 shows a summary of the average projected process unit energy use developed from the energy calculation spreadsheet for the BARDP Desalination Facility. The energy use is presented in kWhr per AF of product water. A detailed table is included in Appendix A.

Table 3-1 Average Process Unit Energy Use Summary

Description	Average Energy Use (kWh/yr)[1]	Unit Energy (kWh/AF)	Process Unit Energy (kWh/AF)
INTAKE			220
Raw Water Pumps	4,700,000	220	
PRETREATMENT			80
Rapid Mixer	6,600	0	
100 Micron Screen	39,000	2	
UF System	150,000	7	
Residuals System	1,400,000	65	
Chemicals System	35,000	2	
DESALINATION			1,310
BWRO Booster Pump	4,300,000	200	
BWRO High Pressure Pump	24,000,000	1,120	
SWRO Interstage Pump	3,100,000	150	
Energy Recovery Device	-3,800,000	-180	
Brine Disposal Pump	440,000	20	
Chemicals System	14,000	0	
POST-TREATMENT			10
Chemicals System	130,000	10	
MISCELLANEOUS			80
HVAC, Lights & Misc.	1,700,000	80	
Total	**36,000,000**	**1,700**	**1,700**

Notes: [1]The overall facility energy use will vary depending on the time of year and salinity of the source water. This table presents average energy use by treatment system, based on monthly average values, to show the relative differences between the different treatment process energy use. See below for discussion of impacts of temperature and salinity on desalination energy use values.

Figure 3-3 summarizes the approximate energy use, on a kWh/AF unit energy basis, of the major components of the BARDP Desalination Facility. The intake, pretreatment, post-treatment and miscellaneous energy uses for the facility are relatively low and remain relatively constant regardless of the quality and temperature of the source water to the facility. The brackish water RO system desalination energy use, however, will vary depending upon the salinity and temperature of the source water. The higher the salinity or the colder the temperature of the source water, the more energy it takes to remove the salt to meet the water quality objectives.

Figure 3-3 Estimated Energy Use by BARDP Desalinated Water Facility

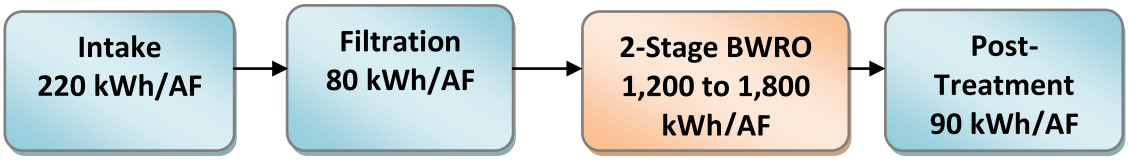
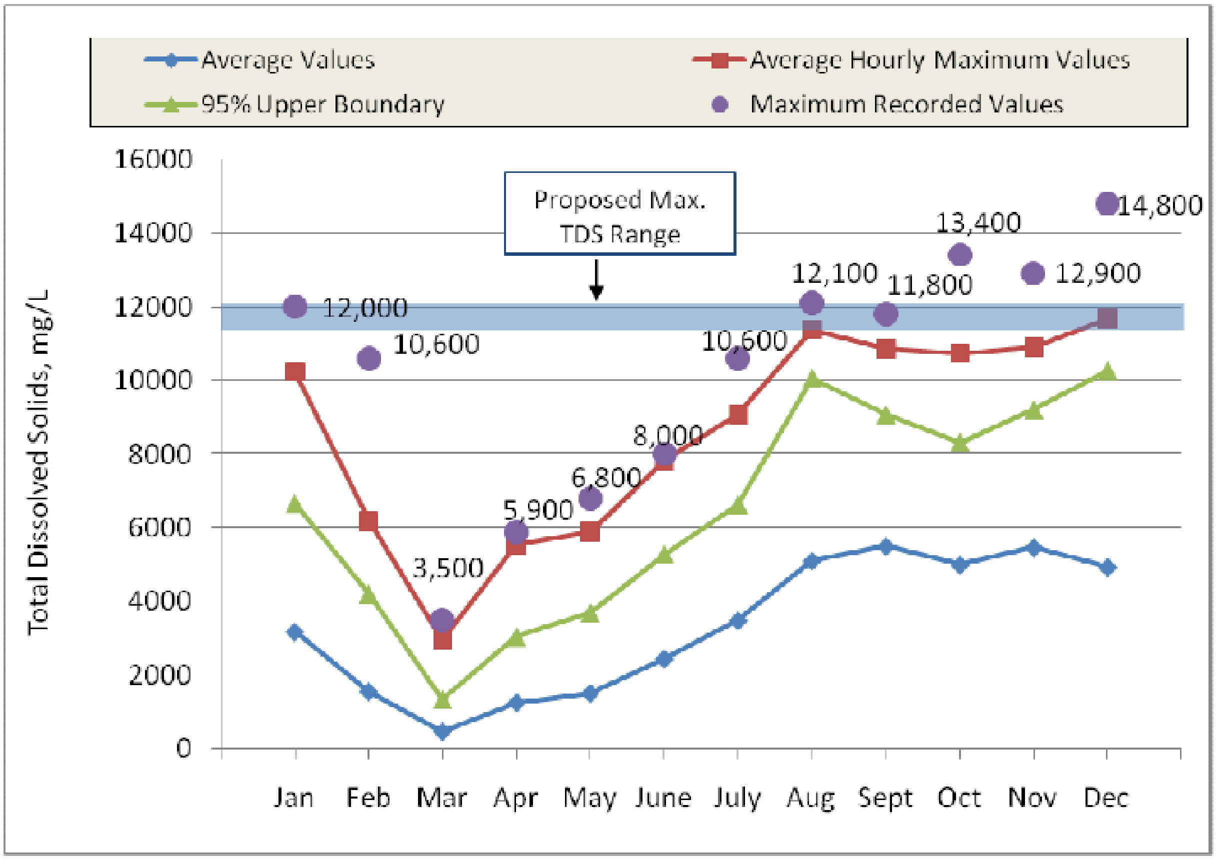


Figure 3-4 shows the average and 95 percentile salinity values for the Mallard Slough source water for the BARDP Desalination Facility. This figure, originating from the 2010 Pilot Report, shows the monthly and maximum daily salinity variation in the source water. The intake salinity in the Mallard Slough varies monthly, with lower average total dissolved solids (TDS) values in February through June. Normal years also have lower average TDS values compared to dry or drought years. While the specific two-stage brackish water treatment process would be designed to treat the design maximum hourly salinity values of 12,000 mg/L, the overall energy use by the system is calculated using the monthly average values.

Figure 3-4 BARDP Desalination Facility Mallard Slough Source Water Salinity Variation (Source: 2010 Pilot Report)



Based on input from the Partners, the following assumptions were used to determine an annual unit energy use factor for the BARDP Desalination Facility:

- The BARDP Desalination Facility typically will produce an average of 20 mgd desalinated product water (intake of up to 25 mgd) or the equivalent to produce 22,400 AFY.
- The facility would not operate in April of each year due to restrictions on CCWD's operations.
- The average salinity values represent a normal year source water condition.
- The 95 percentile salinity values represent a dry or drought year source water condition.

Table 3-2 shows the estimated monthly BARDP Desalination Facility production, source water salinity (TDS) and the resulting process unit energy factor by month for both normal and drought years. The average annual unit energy use also is summarized for both normal and drought years.

Table 3-2 Facility Monthly Water Production, Intake Salinity, and Water Production Energy Factor

Month	Monthly Water Production (AF)$^{(2)}$	Normal Year		Drought Year	
		Average TDS (mg/L)[1]	Process Unit Energy Factor (kWh/AF)	Average TDS (mg/L)[3]	Process Unit Energy Factor (kWh/AF)
January	2,070	3,200	1,870	6,500	2,440
February	1,870	1,600	1,640	4,200	2,130
March	2,070	500	1,450	1,200	1,890
April	0	1,300	--	3,000	--
May	2,070	1,500	1,330	3,500	1,730
June	2,000	2,400	1,370	5,500	1,780
July	2,070	3,100	1,380	6,500	1,790
August	2,070	5,000	1,610	10,000	2,100
September	2,000	5,300	1,720	9,000	2,230
October	2,070	4,700	1,700	8,200	2,220
November	2,000	5,300	1,910	9,200	2,480
December	2,070	4,800	1,980	10,200	2,570
Total	**22,400**	**--**	**1,630**	**--**	**2,120**

Notes:

[1] Average salinity values from Pilot Plant Engineering Report (MWH, 2010).
[2] Annual water production is estimated to be approximately 22,400 AFY (20 MGD). The estimated production was distributed through 11 months to achieve the production goal.
[3] 95th percentile salinity values from Pilot Plant Engineering Report (MWH, 2010).

The overall BARDP Desalination Facility water production energy factor is estimated to be approximately 1,630 kWh/AF in normal years and 2,120 kWh/AF in dry or drought years. These factors will be used to develop energy projections for the BARDP Desalination Facility, as described in Section 4. The average annual energy use of the BARDP Desalination Facility also will be used for subsequent calculation of indirect GHG emissions. Note that the process unit energy factor does not include delivery energy use, which will be accounted for in a separate factor.

3.2.2 Brackish Water versus Seawater Desalination Energy Use

A brackish water desalination process, such as proposed for the BARDP Desalination Facility, uses much less energy than a typical seawater desalination process. The primary difference in energy use is due to the lower salinity and higher temperature of the BARDP Desalination Facility source water. The average salinity of the brackish water source water for the BARDP Desalination Facility is 4,000 to 6,000 mg/L, whereas the typical Pacific Ocean seawater salinity is 32,000 to 35,000 mg/L. The higher salinity of the ocean, combined with colder water temperatures, means that seawater desalination requires much more energy than brackish water desalination. For example, the proposed scwd^2 Regional Seawater Desalination Project in Santa Cruz, California is estimated to require approximately 4,750 kWh/AF to produce potable water; which is two to three times the amount of energy required for BARDP Desalination Facility to produce potable water.

3.2.3 Opportunities for Potential BARDP Desalination Facility Energy Reduction

The projected energy of the BARDP Desalination Facility's brackish water desalination process described in the previous section incorporates the following operational, energy efficiency and energy reduction measures:

- High-efficiency motors (95 percent efficiency rating) for all pumps
- High-efficiency variable frequency drives (VFDs) for pump controls
- Advanced, high-efficiency inter-stage boost, energy recovery devices (ERD) for the brackish water RO system
- System product water recovery in the range of 75 to 83 percent, depending on source water salinity

The BARDP Desalination Facility potentially could optimize or further reduce the overall facility energy use through the following operational and design strategies:

- **Operating at higher flow rates during lower salinity periods**: Depending on monthly and annual Partner water demands, the BARDP Desalination Facility potentially could operate at higher flow rates during lower salinity periods and reduced flow rates during high salinity periods. This potentially could save up to 50 kWh/AF or approximately 3 percent of facility unit energy use. Note, however, that higher flow rates require greater plant capacity and therefore higher capital costs.
- **Designing the process to incorporate "station-design" concepts for pumping**: This approach uses fewer, larger pumps in common header "stations" versus individual pumps associated with each brackish water RO train. Larger pumps typically have higher efficiencies than smaller pumps. This approach to save energy and operations costs has capital cost and operational flexibility trade-offs that should be evaluated in the design phase of the project. This potentially could save approximately 2 to 3 percent of facility unit energy use.
- **Designing the process to eliminate intermediate pumping**: The MF product water break tank and the brackish water RO booster pumps could be eliminated to help save the energy lost through the inefficiencies of two pumps versus one pumping system. This approach to save energy and operations costs has capital cost and operational flexibility trade-offs that should be evaluated in the design phase of the project. This potentially could save up to approximately 2 to 3 percent of facility unit energy use.

The potential for the BARDP Desalination Facility to operate at lower system recoveries of approximately 70 to 75 percent also was evaluated. However, this did not significantly reduce the energy for the facility. The slight reduction in brackish RO system energy use was offset by a slight increase in pretreatment system energy use because of the higher system feed flows to produce the target capacity of potable water production.

Nanotechnology and other future technical improvements to RO membranes may provide additional energy savings. Innovative technologies, approaches and strategies to reduce the energy associated with desalination also may help to cost-effectively further reduce system energy requirements in the future. Potential emerging technologies and approaches include:

- **Nanotechnology-Modified RO Elements:** The RO elements are engineered using nano-particle technology that permits the RO system to produce the same amount and quality of treated water using less energy. These elements became commercially available in the past few years and are starting to be used in full-scale facilities.

- **Direct Osmosis-High Salinity Cleaning**: This system periodically introduces brine to the feed side of the RO elements to help clean the RO membranes. The natural osmotic forces from the brine draw permeate back through the RO element to “backwash” the element. This procedure helps to reduce fouling and reduce the overall energy required to operate the RO system. This process has been used successfully at desalination facilities in Israel.

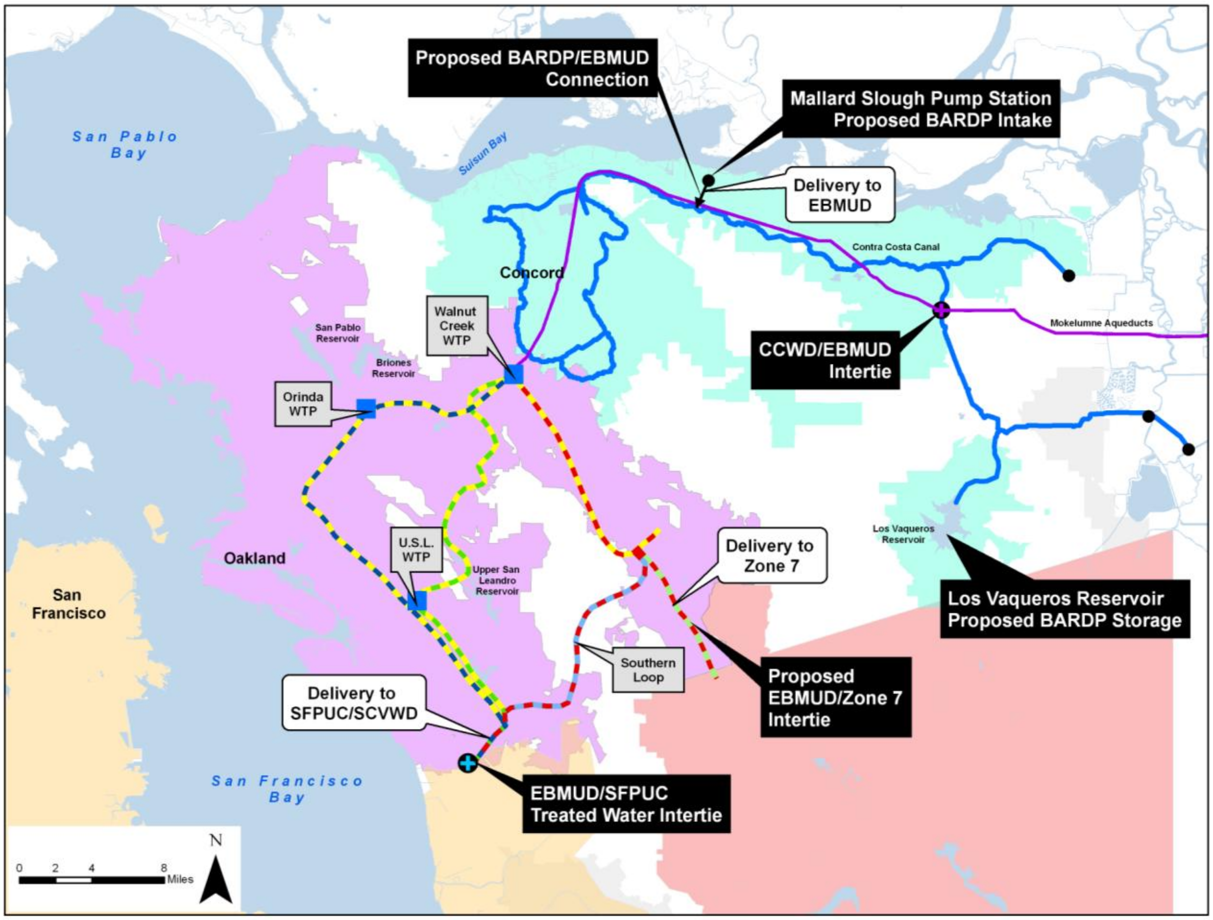
- **Closed Circuit Desalination:** Closed circuit desalination (CCD) is an emerging approach to brackish water and seawater desalination that potentially could reduce energy by 10 percent or more compared to conventional RO desalination. The CCD process operates in a semi-batch mode using conventional RO elements in a 3- or 4-membrane array. After the RO permeate exits the pressure vessel, the still-pressurized concentrate is returned to the front of the vessel and the process continues until it reaches the desired recovery. The vessel then is flushed with fresh feed water, and the process is repeated. CCD balances the flux across the RO elements and operates at a lower average pressure than conventional RO. The CCD process was commercialized in 2012 and may become a viable option once it becomes a more commercially-proven technology.

While there is potential for additional energy savings through final design and operations strategies, Kennedy/Jenks recommends that these additional energy savings approaches not be included in the GHG analysis at this stage of the project. This provides a more conservative approach to understanding the potential energy use and indirect GHG emissions of the BARDP Desalination Facility. If innovative design elements can be incorporated into the project during design, the energy use and GHG projections for the project would be updated at that time to include those savings.

3.2.4 Desalinated Water Direct Delivery Energy Use

Figures 3-2, above and 3-5 below, show how desalinated water would be delivered under a “direct” production and delivery approach, to the Partner Agencies to meet the BARDP Partners supplemental supply objectives. Desalinated product water from the BARDP Desalination Facility would be pumped into CCWD’s MPP for delivery to CCWD customers, and would be pumped into EBMUD’s Mokelumne Aqueduct #3 (MA #3) for delivery to EBMUD’s water treatment plants and subsequent delivery to other Partners. The EBMUD’s Mokelumne Aqueduct #3 carries untreated surface water, so the desalinated water would be re-filtered at the EBMUD Walnut Creek Water Filtration Plant. The re-filtered desalinated water would then be pumped to the Partners through the EBMUD’s treated water distribution system. For Zone 7, the desalinated water would be delivered through the Danville and San Ramon Pump Stations. For SCVWD and SFPUC, the desalinated water would be delivered through the EBMUD Hayward Intertie.

Figure 3-5 BARDP Desalinated Water Delivery to Partner Agencies



The desalinated water delivery energy factors were developed by the BARDP Partners through modeling of their water systems and interconnections and is summarized Table 3-3 below.

Table 3-3 Desalinated Water Direct Delivery Energy Factor, kWh/AF

Agency	Desalinated Water Production, kWh/AF	Energy to Boost into CCWD MPP, kWh/AF	Energy to Boost into EBMUD MA #3, kWh/AF	Additional Treatment and Delivery, kWh/AF[1]	Total Direct Delivery Energy Factor, kWh/AF[2]
CCWD	1,630 – 2,120	600	--	--	2,230 – 2,720
EBMUD	1,630 – 2,120	--	750	350	2,730 – 3,220
SCVWD	1,630 – 2,120	--	750	630	3,010 – 3,500
SFPUC	1,630 – 2,120	--	750	630	3,010 – 3,500
Zone 7	1,630 – 2,120	--	750	610	2,990 – 3,480

Notes:

[1] Includes energy for treatment at the EBMUD Walnut Creek WFP and pumping through the distribution systems to the Partner Agencies.

[2] The energy factor for direct delivery to the Partner Agencies. Indirect storage adds additional energy as described below.

3.2.5 Desalinated Water Indirect To Storage and From Storage Energy Use

The desalinated water from the BARDP Desalination Facility could also be indirectly stored via exchange in CCWD's Los Vaqueros Reservoir for later delivery to partners. The energy requirement for the indirect delivery of product water to the Los Vaqueros Reservoir for storage includes: production of the desalinated water, delivery of the desalinated to the CCWD distribution system, and pumping of the exchange water from the Delta to the reservoir.

Desalinated product water would be exchanged for CCWD's other surface water supplies (Delta water) delivered to the CCWD's Los Vaqueros Reservoir. CCWD estimates the exchange water pumping energy to be 400 kWh/AF, less the energy CCWD saves on treatment, (approximately 150 kwh/AF), for a total indirect energy factor of 250 kWh/AF. This net energy usage would be applied only to the desalinated water supply energy when water is indirectly sent to storage via exchange.

Table 3-4 summarizes the energy for indirect storage of desalinated water in the CCWD's Los Vaqueros Reservoir via exchange.

Table 3-4 Desalinated Water to Storage Energy Factor, kWh/AF

Agency[1]	Desalinated Water Production, kWh/AF	Indirect Water to Storage, kWh/AF[2]	Total To Storage Energy Factor, kWh/AF
CCWD	1,630 – 2,120	850	2,480 – 2,970
EBMUD	1,630 – 2,120	850	2,480 – 2,970
SCVWD	1,630 – 2,120	850	2,480 – 2,970

Notes:

[1] The SFPUC and Zone 7 Partners would always take direct delivery and do not anticipate using storage in Los Vaqueros Reservoir.

[2] Include 600 kWh/AF for delivery of desalinated water to CCWD distribution and 250 kWh/AF for pumping of exchanged Delta water to the reservoir.

Withdrawing water from storage would not use any energy, since the water would flow by gravity from the Los Vaqueros Reservoir to the existing raw water conveyance systems. Stored “indirect desalinated water” for CCWD would be directed to the Contra Costa Canal and treated through the existing surface water treatment system. Stored “indirect desalinated water” for the other Partners would be directed to the EBMUD’s Mokelumne Aqueduct #3. Table 3-5 summarizes the energy for delivery from storage of the indirect desalination water stored in the CCWD’s Los Vaqueros Reservoir.

Table 3-5 Desalinated Water from Storage Energy Factor, kWh/AF

Agency[1]	Additional Treatment and Delivery From Storage, kWh/AF[2]
CCWD	150
EBMUD	350
SCVWD	630

Notes:

[1] The SFPUC and Zone 7 Partners would always take direct delivery and do not anticipate using storage in Los Vaqueros Reservoir.

[2] Includes energy for treatment and pumping through the distribution systems to the Partner Agencies.

3.3 Overall Desalinated Water Supply Energy Factor

The estimated energy for the BARDP desalinated water supply production, delivery, and indirect storage, in kWh/AF, is summarized in Table 3-6. The overall desalinated water supply energy use is shown as a range because the energy associated with sending water indirectly to storage, or taking water from storage, could vary from year to year, depending on the water supply plans of the individual Partners. Also, the energy for the production of desalinated water will vary depending on the overall salinity in the source water during normal and drought years.

Table 3-6 Overall Desalinated Water Supply Energy Factors, kWh/AF

Agency	Total Direct Delivery Energy Factor, kWh/AF[1]	Total To Storage Energy Factor, kWh/AF	From Storage, kWh/AF
CCWD	2,230 – 2,720	2,480 – 2,970	150
EBMUD	2,730 – 3,220	2,480 – 2,970	350
SCVWD	3,010 – 3,500	2,480 – 2,970	630
SFPUC	3,010 – 3,500	--	--
Zone 7	2,990 – 3,480	--	--

Notes:

[1] The desalinated water energy is shown as a range. The lower range includes normal year production and indirect storage or delivery. The high range includes dry year production and direct delivery. Section 4 describes and calculates the desalinated water supply energy using the individual energy factors and 30-year water delivery and storage projections for each of the BARDP Partners.

Based on the water supply projections of the BARDP Partners, the energy factors for the components of the desalinated water supply (production, direct delivery, indirect storage and delivery) are used to develop energy use and GHG emission projections for the project.

Section 4: Desalination Supply Energy and GHG Projections

This section describes and calculates the projected BARDP desalination energy use and associated indirect GHG emissions. The projections estimate the energy use for the BARDP to supply water to meet the project goals and anticipated needs of the Partners.

4.1 Role of Projections in Energy Minimization and GHG Reduction Plan Implementation

The water production, energy consumption, and GHG projections developed in this GHG Analysis are used only for developing a plan to reduce the applicable water supply GHG emissions and for budgeting purposes. Once the BARDP is in operation, the energy use for the BARDP Desalination Facility and various water supply components would be taken from actual meter or billing data to calculate the annual GHG emissions.

The Energy Plan projections periodically would be updated and re-evaluated to confirm that the desalination supply GHG emissions are being reduced in an efficient and cost-effective manner. The Energy Plan also will include an adaptation plan to address potential future changes in operations, demands, and energy supply that would impact project GHG reductions. Therefore, the order of magnitude, rather than the exact value, of the estimated emissions will be most useful to the Partners to plan for what size, type, and number of GHG reduction and offset projects to pursue, in order to meet their respective GHG reduction goals.

4.2 Projected Desalinated Water Supply Water Use

As discussed in Section 3, the anticipated use of the BARDP desalinated water supply would occur in three ways:

- **Direct Delivery** – BARDP Desalination Facility produces water that is directly distributed to Partners via CCWD’s MPP or EBMUD’s Mokelumne Aqueduct #3.
- **Indirect To Storage –** BARDP Desalination Facility produces water that is transferred via exchange with CCWD to storage in Los Vaqueros Reservoir for future use
- **From Storage** – Previously “indirectly stored” desalinated water is withdrawn from Los Vaqueros Reservoir and distributed to Partners via EBMUD’s Mokelumne Aqueduct #3

It is important to differentiate these three uses because the energy and associated indirect GHG emissions will vary depending upon the use. It also is important to consider, not only which Partner participates in these uses, but when, since the drought status of the year in which each use occurs will affect the amount of indirect GHG emissions associated with the BARDP desalinated water supply.

The projected desalination supply use by the Partners was developed by the Partners based on water supply projections from each Partner's latest Urban Water Management Plan (UWMP) and other recent planning documents. Whether Partners rely on the direct delivery or indirect stored desalinated water supply (or both) generally depends on the hydrologic conditions for a given year. Hydrologic conditions can be described as wet, above normal, normal, below normal, dry, and critically dry, although some agencies may simply use normal and dry to characterize conditions and indicate their need for water supply from the BARDP. The hydrology of each year was modeled based on historical conditions from 1970 to 2000 and varies by agency. For planning purposes in this GHG Analysis, two different hydrologic conditions were used for modeling: a normal year and a dry/drought year.

Table 4-1 shows the estimated BARDP Partner desalinated water use for the period 2020 to 2030, broken down by each Partner agency and each use. Based on the anticipated schedule for the BARDP, the year 2020 was selected as the first year of operations for the BARDP Desalination Facility. Appendix B provides additional information on how the projections were calculated, as well as the 30-year projections. Note that in Table 4-1, the years 2020-2025 and 2030 are considered normal hydrologic years, while years 2026 through 2029 are assumed to be dry or critically dry/drought years.

Table 4-1 Projected Desalination Use, 2020 – 2030

Partner	Projected Annual Water Supply (AFY)					
	Normal Years	Dry or Drought Years			Normal Year	30-Yr Average
	2020 – 2025	2026	2027	2028 – 2029	2030	
CCWD						
Direct	0	0	2,700	0	0	350
To Storage	1,500	0	0	0	1,500	980
From Storage	0	0	8,100	0	0	590
EBMUD						
Direct	0	3,200	1,900	6,700	0	1,200
To Storage	2,500	0	0	0	2,500	1,600
From Storage	0	6,900	5,600	0	0	950
SCVWD						
Direct	0	3,500	2,100	0	0	800
To Storage	2,700	0	0	0	2,700	1,800
From Storage	0	7,700	6,300	0	0	1,100
SFPUC						
Direct	10,100	10,100	10,100	10,100	10,100	10,100
Zone 7						
Direct	5,600	5,600	5,600	5,600	5,600	5,600
Total Desalination Use (Direct + From Storage)	**15,700**	**36,900**	**42,400**	**22,400**	**15,700**	**20,700**
Total Desal Facility Production (Direct + To Storage)	**22,400**	**22,400**	**22,400**	**22,400**	**22,400**	**22,400**

The differences in direct use, storage, or indirect use of the desalination supply by the different Partners, as shown in Table 4-1, are based on the different water management strategies of the different agencies. The total annual desalinated water use (Direct + From Storage) varies annually and can exceed the BARDP Desalination Facility capacity due to use of stored desalination. However, the total annual desalination production from the BARDP Desalination Facility (Direct + To Storage) is anticipated to be constant at 22,400 AFY.

4.3 Projected Desalinated Water Supply Energy Use

The projected energy use of the BARDP desalinated water supply was estimated by multiplying each type of desalinated water use (direct delivery, indirect to storage, and from storage) by the associated energy unit factors for that use.

- **Direct Delivery**: includes the BARDP Desalination Facility water production factor (described in Section 3) plus the Partner-specific direct delivery energy factor. The amount of pumping energy required to deliver the desalinated water will vary by agency based on distance and elevation differences relative to the agency tie-in. In addition, some Partners' supply from the BARDP may require additional treatment; specifically, desalinated water delivered to EBMUD's Mokelumne Aqueduct #3 (for subsequent use by EBMUD, SCVWD, SFPUC, and Zone 7) will require additional treatment since Mokelumne Aqueduct #3 is a raw water pipeline..

- **Indirect to Storage**: includes the BARDP Desalination Facility unit energy factor plus the pumping energy required to lift water (via exchange with CCWD surface supplies) to the Los Vaqueros Reservoir. The amount of energy used to deliver the water to storage is assumed to be distributed among the Partners based on the percentage that each Partner uses the stored desalination through "indirect use".

- **From Storage:** includes just the Partner-specific distribution unit energy factor, since the desalination treatment energy and the energy to send the water to storage has already been accounted for in the "to storage" amount.

The estimated annual energy use for the BARDP desalination supply from 2020 to 2030 is summarized in Table 4-2; projections for 2020 to 2050 are included in Appendix B.

Table 4-2 Projected Desalinated Water Energy Use, 2020 – 2030

Partner	Projected Annual Energy Use (MWh/year)					
	Normal Years	Dry or Drought Years			Normal Year	30-yr Average
	2020 - 2025	2026	2027	2028 – 2029	2030	
CCWD	3,800	0	8,200	0	3,800	3,500
EBMUD	6,100	11,000	6,700	21,000	6,100	8,100
SCVWD	6,800	15,000	8,700	0	6,800	7,900
SFPUC	30,000	35,000	35,000	30,000	30,000	32,000
Zone 7	17,000	19,000	19,200	17,000	17,000	17,000
Total Desalination Supply Energy Use	**64,000**	**81,000**	**78,000**	**68,000**	**64,000**	**69,000**

4.4 Projected GHG Emissions

4.4.1 GHG Emissions Considered

A facility, such as a power generation site, that directly emits GHGs is considered to produce *direct* emissions. A facility or site, such as a business, or a water treatment plant that consumes energy from purchased electricity is considered to have *indirect* emissions because they indirectly create the demand for electricity, which is generated in part using GHG-producing fossil fuels.

Since the operation of the BARDP Desalination Facility and associated pump stations would consume energy from purchased electricity, it primarily would be an indirect emitter. Construction of the project will produce one-time direct GHG emissions due to the use of construction equipment and vehicles. Operations of the facility will also produce a small amount of direct GHG emissions from vehicle trips and potentially from a small emergency generator for lighting and control power.

In the future Energy Plan, which would be developed once the BARDP is operational, both direct and indirect potential GHG emissions would be taken into consideration. Since the majority of GHG impacts are from indirect emissions, only indirect GHG emissions are discussed in this report.

4.4.2 BARDP Desalination Facility Energy Supplier

The indirect emissions associated with BARDP originate from the use of electricity provided by an energy supplier. The Partners could negotiate a power arrangement directly from a nearby power generating facility or purchase energy from the power grid, supplied by Pacific Gas and Electric (PG&E). Obtaining power directly from a nearby generating facility has the following issues:

- Local power generating facilities currently are “peaking plants” that do not operate continuously. The Partners would have to secure other power supply agreements for BARDP to have full-time reliable operations.

- Local fossil fuel-burning generating facilities have higher emissions factors than PG&E, which has a portfolio that includes renewable energy sources; this would cause BARDP to have higher associated indirect emissions.

For this analysis, the energy supply for the BARDP Desalination Facility is assumed to be electric power from the power grid supplied by PG&E.

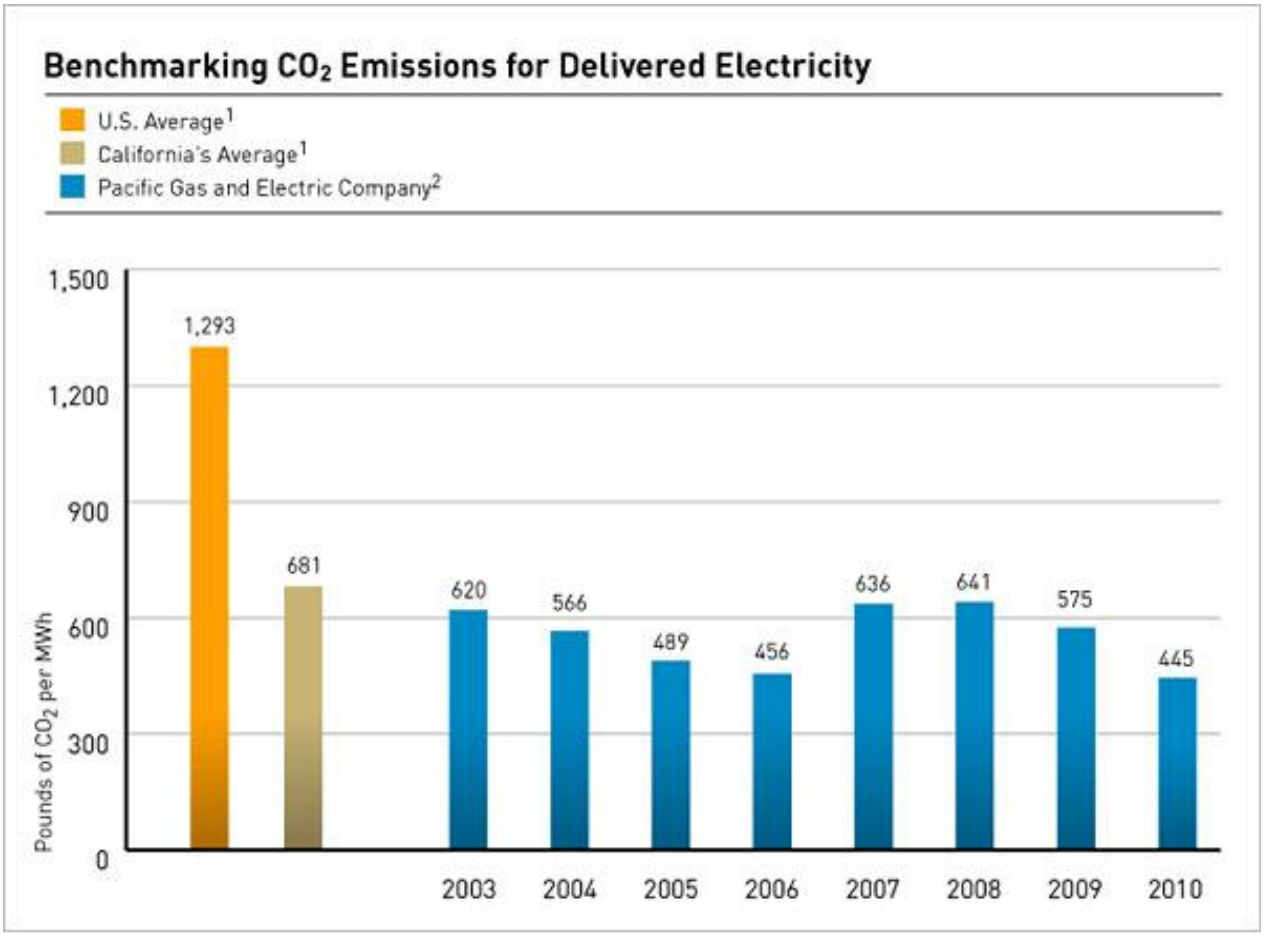
4.4.3 GHG Emissions Factors

PG&E’s energy portfolio has a varying amount of GHGs for every kWh produced, depending on the mix of renewable and non-renewable energy sources. Each year PG&E publishes a certified emissions factor to determine the amount of GHG emissions that are associated with the electrical energy delivered and used by consumers. Indirect GHG emissions were calculated using PG&E California Climate Action Registry reported and verified electricity CO_2e emissions factors. The annual report can be found at: http://www.theclimateregistry.org/public-reports/. As shown in Figure 4-1, the emissions factor fluctuates annually and often is greater in dry and drought years due to less available hydropower.

Over time, PG&E anticipates that its energy portfolio will shift toward more renewable sources. For the purposes of projecting future GHG emissions for BARDP, this analysis uses a publicly-available California Public Utilities Commission (CPUC) GHG calculator that estimates the projected PG&E emissions factors for 2016 through 2020. This emissions factor has been recommended by PG&E for future planning (PG&E, 2011). The projections assume that the PG&E will increase its renewable portfolio to meet AB32 goals by 2020, and the emissions factor will decrease from 391 pounds CO_2e per MWh in 2015 to 290 pounds CO_2e per MWh in 2020 (Energy and Environmental Economics, Inc., 2010). To account for an expected decrease in hydropower in drought years, the expected drought year emissions factor has been increased to 350 pounds CO_2e per MWh, or 20 percent greater than the current PG&E planning factor.

In implementing the Energy Plan for BARDP, the actual PG&E emissions factor for each future year would be used to determine the actual indirect GHG emissions.

Figure 4-1 PG&E CO_2e Emissions Factor, 2003 – 2010



[1] Source: U.S. Environmental Protection Agency eGRID2010 Version 1.1, which contains year 2007 information configured to reflect the electric power industry's current structure as of December 31, 2010.

[2] Because PG&E purchases a portion of its electricity from the wholesale market, we are not able to track some of our delivered electricity back to a specific generator. Therefore, there is some unavoidable uncertainty in PG&E's total emissions and emissions rate for delivered electricity.

Source: PG&E, 2012.

4.4.4 Other Assumptions

Other general assumptions used in this section include:

- The conversion factor used to convert emissions from pounds CO_2e to MT CO_2e is 2,204.6 pounds per MT.
- CH_4 and N_2O emissions are considered negligible compared to CO_2e emissions and are not included in this analysis.

4.5 Projected BARDP Desalinated Water Supply Indirect GHG Emissions

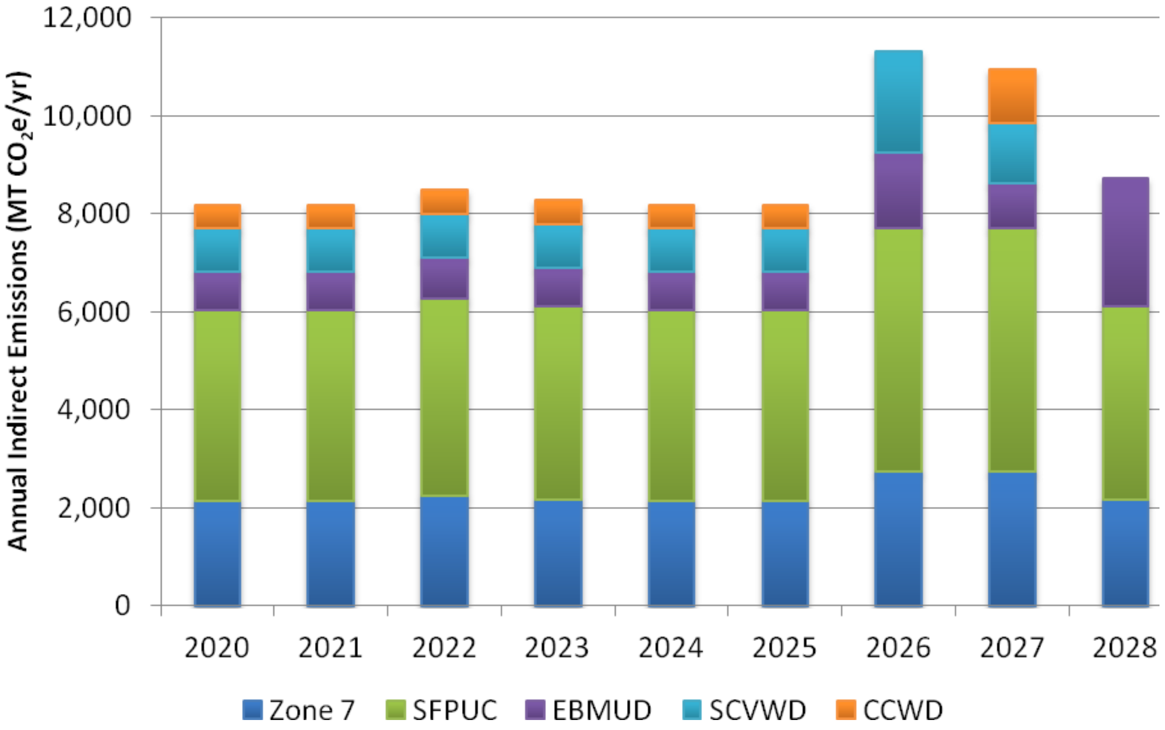
The projected indirect GHG emissions of the BARDP desalination supply were estimated by multiplying each type of desalination supply use, as shown in Table 4-1, by the associated energy and emissions factors for that use. While the BARDP Desalination Facility and the storage pumping are expected to use 100 percent PG&E electricity, the Partner-specific desalinated water delivery uses energy from various sources, such as Modesto Irrigation District (MID), SFPUC hydropower, or local solar power. The specifics of the distribution system pumping energy and emissions are provided in Appendix B.

The estimated annual indirect emissions for the BARDP system from 2020 to 2030 and the thirty-year average are summarized in Table 4-3; the detailed thirty-year projections are included in Appendix B. The projected annual indirect GHG emissions are shown by agency, as well as by the total project amount. Figure 4-2 shows the indirect GHG emissions information graphically.

Table 4-3 Projected Desalination Supply Indirect GHG Emissions

Partner	Projected Annual Indirect Emissions (MT CO_2e/year)					
	Normal Years	**Dry or Drought Years**			**Normal Year**	**30-yr Average**
	2020 - 2025	**2026**	**2027**	**2028-2029**	**2030**	
CCWD	490	0	1,160	0	490	470
EBMUD	780	1,560	920	2,690	790	1,060
SCVWD	870	2,050	1,220	0	880	1,070
SFPUC	3,900	4,960	4,960	4,050	3,940	4,280
Zone 7	2,150	2,740	2,740	2,170	2,170	2,360
Total Desalination Indirect Emissions	**8,180**	**11,310**	**11,000**	**8,970**	**8,280**	**9,240**

Figure 4-2 Projected Desalination Supply Indirect GHG Emissions



Section 5: Potential GHG Reduction Goals

This section describes two potential GHG reduction goals for the BARDP and estimates the amount of indirect GHG emissions that BARDP would have to reduce to meet each of the potential goals.

5.1 Potential GHG Reduction Goal Alternatives

As described in Section 2.1, if implemented, the future BARDP EIR will identify the appropriate GHG TOS for the project under CEQA and will provide the substantial evidence to support that threshold. Depending upon their goals, the Partners either could choose to meet the regulatory requirement of the BARDP TOS or could opt to exceed the regulatory requirement by selecting a greater level of GHG reduction. The amount of GHG reduction required for the Partners will depend upon the GHG reduction goal selected.

This section describes two potential GHG reduction goals for the BARDP and estimates the amount of indirect GHG emissions that BARDP would have to reduce to meet each potential goal. This analysis helps to provide an understanding of the potential magnitude of GHG reduction for BARDP and to develop strategies to meet the range of potential goals.

The two potential GHG reduction goals are:

- Carbon-Free Desalinated Water Supply
- No Net Increase in Water Portfolio (also referred to as Net Carbon Neutral Water Portfolio)

The Carbon-Free Desalinated Water Supply goal depends only on the BARDP facility operation and water delivery energy use. The No Net Increase in Water Portfolio goal depends on the overall water supply portfolio and how it changes due to the addition of the BARDP facility.

5.2 Carbon-Free Desalinated Water Supply Goal

A Carbon-Free Desalinated Water Supply GHG reduction goal would offset all GHG emissions associated with the BARDP desalination supply without consideration of GHG emissions from other water supply sources. The Carbon-Free Desalinated Water Supply threshold for the BARDP would be zero (0) MT CO_2e per year. Adopting a Carbon-Free Desalinated Water Supply goal would mean that each Partner would completely offset their portion of the BARDP GHG emissions, or that the Partners as a group (e.g. as a Joint Powers Authority) would collectively offset all GHG emissions from the BARDP.

There are no regulations in place that would require the reduction or offset of all GHG emissions from the BARDP, but the Partners could choose to select this goal to meet and exceed regulations.

Table 5-1 summarizes the potential average annual emissions that each Partner would need to offset and the total for the entire BARDP program to achieve a Carbon-Free Desalinated Water Supply goal. The table is based on the projected thirty-year annual average indirect GHG emissions from Table 4-3. The thirty-year annual average GHG reduction value is used for planning purposes to evaluate the size and number of potential GHG reduction projects required to meet this goal.

Table 5-1 GHG Reductions for a Potential Carbon-Free Desalinated Water Supply Goal

Partner	Average Annual Indirect GHG Emissions to Reduce (MT CO_2e/year)
CCWD	470
EBMUD	1,060
SCVWD	1,070
SFPUC	4,280
Zone 7	2,360
Total	**9,240**

5.3 No Net Increase in Water Portfolio Goal

A No Net Increase in Water Portfolio GHG reduction goal would require the Partners to maintain the emissions from their total water supply portfolios including the BARDP at the same level as if the BARDP were not implemented. Adopting a No Net Increase in Water Portfolio goal would mean that each Partner would reduce or offset the difference between its water supply GHG emissions with the BARDP and without the BARDP.

5.4 Avoided Emissions

To calculate a No Net Increase in Water Portfolio goal, it is necessary to understand the concept of “avoided emissions” that result from the use of the BARDP water supply. For each gallon of supplemental water supply provided by BARDP, there is a corresponding decrease of one gallon of another water source that would have been used by the Partners. The avoided GHG emissions are due to the avoided energy used for treatment and delivery of these other water sources that are replaced by BARDP. This approach assumes that the Partners’ overall water supply objectives remain the same and that the same level of service to customers is maintained; this also implies that conservation projections have already been incorporated into the water supply/demand projections used in the analysis.

Depending on the avoided emissions, the difference in overall water supply GHG emissions could be:

- An increase in a Partner’s overall water supply emissions (a positive amount)
- No change in a Partner’s overall water supply emissions, if the indirect emissions from the BARDP desalinated water supply equal the indirect emissions of the other water source replaced or reduced by the use of the BARDP

- A decrease in a Partner's overall water supply emissions, if the BARDP replaces a more GHG-intensive water source and thereby reduces the overall water supply emissions (a negative amount)

Calculation of the goal compares the projected 30-year total water supply GHG emissions with BARDP to the projected 30-year total water supply GHG emissions without BARDP for each Partner.

The avoided emissions from a No Net Increase in Water Portfolio goal are calculated as follows:

Desalinated Water Supply Use Emissions

- Emissions of Alternative Water Supply

= Increase (or Decrease) in Emissions from Desalinated Water Use

The following sections discuss and summarize projected avoided emissions and No Net Increase in Water Portfolio emissions goals for each Partner agency. The thirty-year projections for each Partner are included in Appendix C.

5.4.1 CCWD Avoided Emissions and No Net Increase in Water Portfolio Goal

CCWD currently receives over 80 percent of its water supply from Central Valley Project (CVP) surface water. Other water supplies include local surface water, recycled water, groundwater, and planned purchases of other surface water during droughts. The BARDP project would reduce the need for planned purchases of surface water (Planned Purchases) during droughts.

Since CCWD anticipates that it will use an average of approximately 1,920 AFY of desalination over thirty years, it is assumed that the same volume of water would be reduced or avoided from the Planned Purchases source. To calculate the amount of avoided GHGs from this reduction in Planned Purchases, the volume of annual avoided Planned Purchases water is multiplied by its unit energy factor of 765 kWh/AF to estimate the annual energy use. The average annual energy use over thirty years is estimated to be approximately 1,470 MWh/year.

The energy use is then converted to indirect GHG emissions by multiplying the energy use by the emissions factor of the electricity used by that water source. The CCWD Planned Purchases water source uses electricity supplied by the Modesto Irrigation District (MID) for intake pumping and electricity supplied by PG&E for treatment and distribution. In 2009 MID had an emissions factor of 1,036.2 lbs CO_2e/MWh, as published by The Climate Registry (http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/). The emissions factor likely will be lower by 2020, since California utilities in general are investing in more renewable energy. For the purposes of this report, the MID emissions factor is projected to be approximately 830 lbs CO_2e/MWh in non-drought years (20 percent less than in 2009) and 1,000 lbs CO_2e/MWh in drought years. The average annual avoided emissions over thirty years are estimated to be approximately 290 MT CO_2e per year.

As shown in Table 4-3, the average annual BARDP emissions for CCWD are estimated to be 470 MT CO_2e per year. Therefore, the average annual No Net Increase in Water Portfolio emissions reductions for CCWD are 180 MT CO_2e per year (470 – 290 MT CO_2e), which means that CCWD would see an increase in emissions as a result of the BARDP.

Table 5-2 summarizes the avoided emissions and No Net Increase in Water Portfolio reduction amounts for CCWD.

Table 5-2 Summary of No Net Increase in Water Portfolio Approach for CCWD

	Average Annual Supply (AFY)	Average Annual Energy Use (MWh/yr)	Average Annual Indirect Emissions (MT CO_2e/yr)
Addition of Desalinated Water Supply	1,920	3,500	470
Reduction of Surface Water	1,920	1,470	290
No Net Increase Reductions Goal	--	--	**+180**

5.4.2 EBMUD Avoided Emissions and No Net Increase in Water Portfolio Goal

EBMUD currently receives over 80 percent of its water supply from imported surface water (Mokelumne River). Besides conserved water, other water supplies include recycled water, additional imported surface water through the Freeport pipeline and groundwater. The BARDP project would potentially reduce the need in drought years for imported surface water (i.e., transfer water) using the Freeport facilities, which uses electricity from PG&E, Sacramento Municipal Utility District (SMUD), and Western Area Power Administration (WAPA). The EBMUD avoided emissions were calculated using a similar analysis to the CCWD analysis presented in Section 5.4.1 and are summarized in Table 5-3. Detailed calculations are provided in Appendix C.

Table 5-3 Summary of No Net Increase in Water Portfolio Approach for EBMUD

	Average Annual Supply (AFY)	Average Annual Energy Use (MWh/yr)	Average Annual Indirect Emissions (MT CO_2e/yr)
Addition of Desalinated Water Supply	3,700	8,050	1,060
Reduction of Imported Surface Water (Freeport)	3,700	5,840	1,010
No Net Increase Reduction Goal	--	--	**+50**

Although importing Freeport water uses less energy than producing desalination, the indirect emissions are nearly equal due to the different emissions factors associated with the two supplies. The primary use for electricity for importing Freeport water is for conveyance/pumping.

5.4.3 SCVWD Avoided Emissions and No Net Increase in Water Portfolio Goal

SCVWD currently receives the majority of its water supply from imported surface water (a combination of SWP, CVP, and Semitropic) and local surface water. Other water supplies in its service area include water supplied by SFPUC, non-SCVWD local surface water delivered by San Jose Water Company and Stanford, recycled water, and groundwater. The BARDP project would reduce the need to import surface water in drought years. The SCVWD avoided emissions were calculated using a similar analysis to the CCWD analysis presented in Section 5.4.1 and are summarized in Table 5-4. Detailed calculations are provided in Appendix C.

Table 5-4 Summary of No Net Increase in Water Portfolio Approach for SCVWD

	Average Annual Supply (AFY)	Average Annual Energy Use (MWh/yr)	Average Annual Indirect Emissions (MT CO_2e/yr)
Addition of Desalinated Water Supply	3,700	7,900	1,070
Reduction of Imported Surface Water	3,700	6,200	840
No Net Increase Reductions Goal	--	--	**+230**

5.4.4 SFPUC Avoided Emissions and No Net Increase in Water Portfolio Increase Goal

SFPUC currently receives the majority of its water supply from its Regional Water System (RWS). The RWS is geographically delineated between the Hetch Hetchy Project and the Bay Area water system facilities. The Hetch Hetchy Project is generally composed of the reservoirs, hydroelectric generation and transmission facilities, and water transmission facilities from the Hetch Hetchy Valley west to the Alameda East Portal of the Coast Range Tunnel in Sunol Valley. The local Bay Area water system generally consists of the facilities west of Alameda East Portal, and includes the Alameda and Peninsula watershed reservoirs, two water treatment plants and the distribution system that delivers water to the SFPUC’s Retail and Wholesale Customers. The RWS consists of more than 280 miles of pipeline and 60 miles of tunnels, 11 reservoirs, 5 pump stations, and 2 water treatment plants, and comprises three regional water supply and conveyance systems: the Hetch Hetchy System, the Alameda System, and the Peninsula System. Other water supplies include local groundwater and recycled water, which are currently in early implementation phases. Non-potable supplies are also being encouraged in the retail service area.

The BARDP project would reduce the annual demands on the Regional Water System, specifically the additional local groundwater pumping, which would use electricity from SFPUC hydropower facilities. The SFPUC avoided emissions were calculated using a similar analysis to the CCWD analysis presented in Section 5.4.1 and are summarized in Table 5-5. Detailed calculations are provided in Appendix C.

Table 5-5 Summary of No Net Increase in Water Portfolio Approach for SFPUC

	Average Annual Supply (AFY)	Average Annual Energy Use (MWh/yr)	Average Annual Indirect Emissions (MT CO_2e/yr)
Addition of Desalination Supply	10,100	32,000	4,280
Reduction of RWS Water	10,100	14,000	0
No Net Increase Reduction Goal	--	--	**+4,280**

For SFPUC, the avoided emissions would be zero since the local groundwater supply uses electricity from hydropower, which has no GHG emissions.

5.4.5 Zone 7 Avoided Emissions and No Net Increase in Water Portfolio Increase Goal

Zone 7 currently receives the majority of its water supply from imported State Water Project (SWP) surface water. Other water supplies include local surface water, groundwater, brackish groundwater desalination, imported Byron Bethany Irrigation District surface water, and storage of non-local water to be used in droughts. For the purposes of this report, the BARDP project would reduce the annual need for Zone 7 to import as much SWP water, which uses electricity from PG&E, solar power, and SWP hydropower facilities. The Zone 7 avoided emissions were calculated using a similar analysis to the CCWD analysis presented in Section 5.4.1 and are summarized in Table 5-6. Detailed calculations are provided in Appendix C.

Table 5-6 Summary of No Net Increase in Water Portfolio Approach for Zone 7

	Average Annual Supply (AFY)	Average Annual Energy Use (MWh/yr)	Average Annual Indirect Emissions (MT CO_2e/yr)
Addition of Desalinated Water Supply	5,600	18,000	2,360
Reduction of Imported Surface Water	5,600	8,200	1,290
No Net Increase Reduction Goal	--	--	**+1,070**

5.4.6 Total Avoided Emissions and No Net Increase in Water Portfolio Goal

Table 5-7 summarizes the potential annual avoided emissions for each Partner and the total program based on a No Net Increase in Water Portfolio goal and the associated GHG reductions to meet that goal.

Table 5-7 GHG Reductions for a Potential No Net Increase in Water Portfolio Goal

Partner	Average Annual Desalinated Water Emissions (MT CO_2e/year)	Source Replaced	Average Annual Avoided Emissions (MT CO_2e/year)	Average Annual Indirect Emissions to Reduce (MT CO_2e/year)
CCWD	470	Imported Water	290	180
EBMUD	1,060	Imported Freeport Water	1,010	50
SCVWD	1,070	Imported Water	840	230
SFPUC	4,280	RWS Water	0	4,280
Zone 7	2,360	Imported Water	1,290	1,070
Total	**9,240**	--	**3,430**	**5,810**

As shown in Table 5-7, CCWD, EBMUD, and SCVWD would see a small increase in annual GHG emissions due to the addition of the BARDP desalinated water supply to their overall water supply portfolios. The SFPUC and Zone 7 would see a moderate increase in the overall GHG emissions.

5.5 Summary of Carbon Free Desalinated Water Supply and No Net Increase in Water Portfolio Goals

Table 5-8 summarizes the projected average annual GHG reduction levels to meet the two potential GHG reductions goals. In both cases the overall amounts of GHG reductions required to meet the potential goals are relatively modest compared to other desalination projects in California.

Table 5-8 Summary of Potential GHG Reduction Goals

Partner	No Net Increase in Water Portfolio (MT CO_2e/year)	Carbon Free Desalinated Water Supply (MT CO_2e/year)
CCWD	180	470
EBMUD	50	1,060
SCVWD	230	1,070
SFPUC	4,280	4,280
Zone 7	1,070	2,360
Total	**5,810**	**9,240**

For the two potential goals, Figures 5-1 and 5-2 show the potential indirect GHG emissions to reduce for the total BARDP project and for each Partner, respectively.

Figure 5-1 Potential BARDP Indirect GHG Emission Reductions

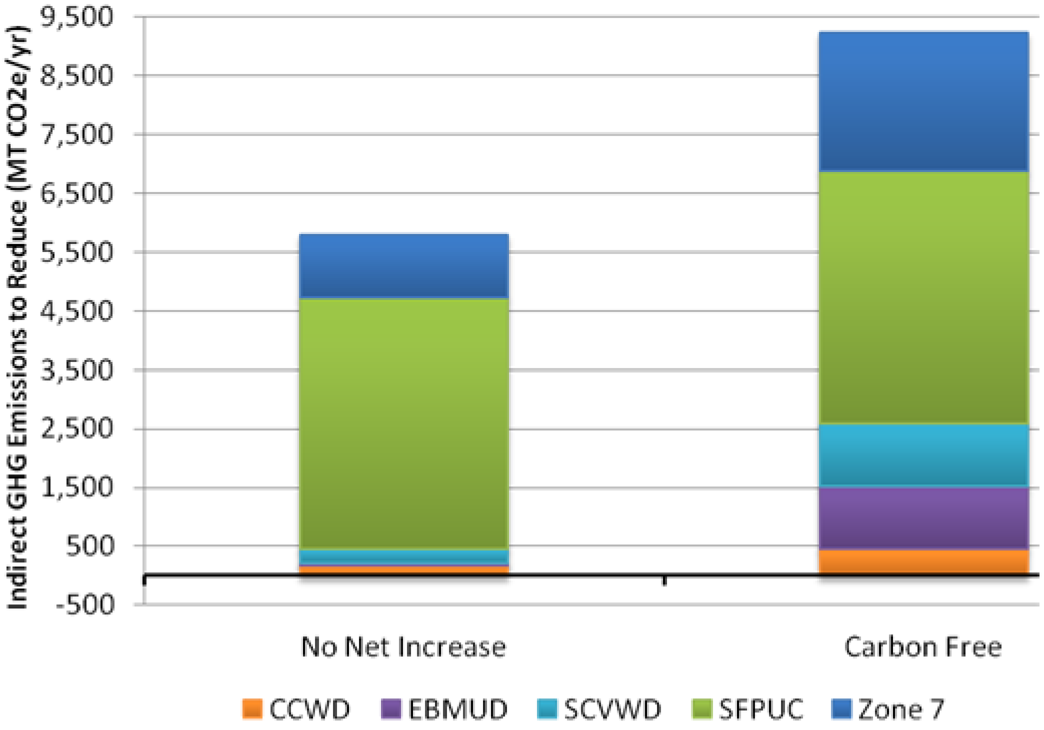
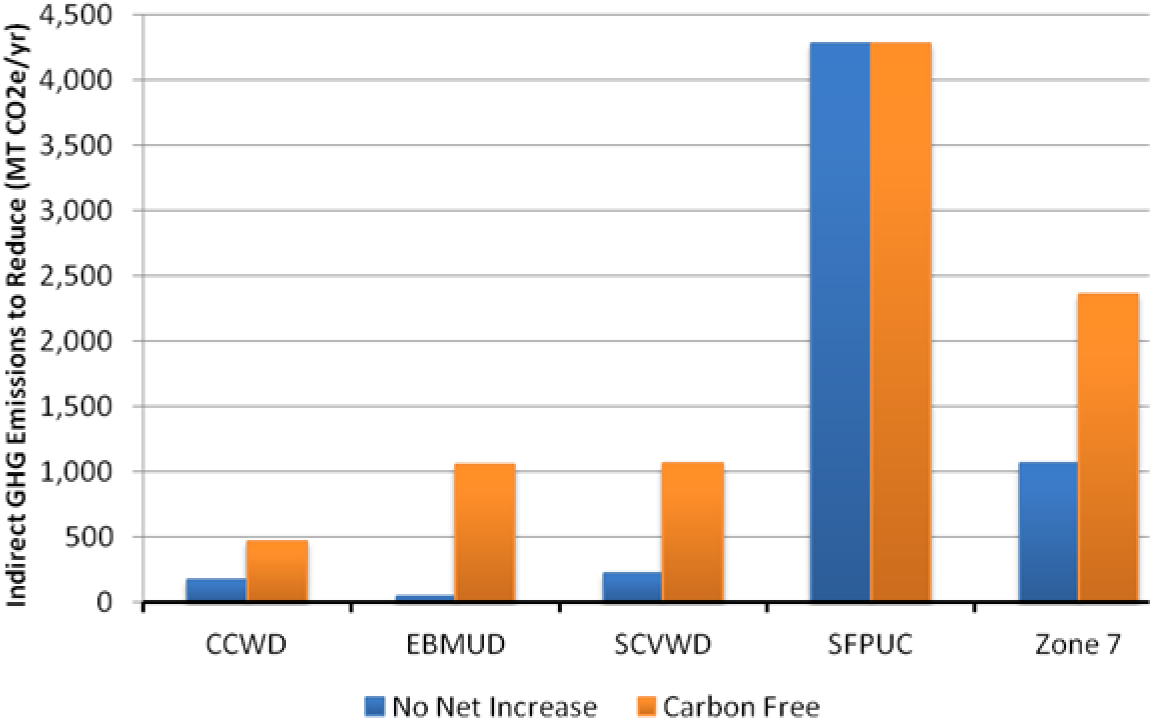


Figure 5-2 Potential Partner GHG Emission Reductions



Section 6: Potential GHG Reduction Strategies and Actions

This section identifies, evaluates and summarizes potential GHG reduction strategies and projects for the BARDP that are based on strategies that have been shown to be cost-effective for other California desalination projects and water utilities, while considering their specific applicability to the BARDP.

6.1 Conceptual-Level GHG Reduction Strategies and Actions

As discussed in Section 5, the annual amount of GHG reduction for the BARDP could range from approximately 5,810 MT CO_2e per year for a No Net Increase in Water Portfolio goal to 9,240 MT CO_2e per year for a Carbon-Free Desalinated Water Supply goal. This study identifies recommended conceptual-level strategies and projects for a GHG reduction portfolio that could meet this range of GHG reduction.

To meet either goal, the Partners could pursue a variety of GHG reduction projects and programs. Detailed analysis and development of specific GHG reduction projects and goals for the Partners is beyond the scope of this project. However, this report presents conceptual level GHG reduction strategies and projects, and the associated GHG reduction amounts and cost estimates (based on past experience by Kennedy/Jenks) presented in dollars per acre-foot of treated water capacity.

Although there are many ways to compile a portfolio of GHG reduction projects, in general Kennedy/Jenks recommends that the Partners evaluate projects starting at the BARDP facility and radiating out by jurisdiction and geographically. First, the Partners could look within the desalination facility boundary to identify projects (such as energy recovery, solar PV panels and green building design) to reduce the amount of energy purchased. Next, the Partners could evaluate projects to reduce their overall agency energy use and carbon footprint. The Partners then could explore options to build local renewable projects or provide rebates for Partner customers and businesses to create energy or GHG reduction projects. Finally, the Partners could explore projects in the general region and beyond.

6.2 GHG Reduction Project and Program Types

The following sections provide a discussion of the three general types of potential GHG reduction projects.

6.2.1 Water and Energy Efficiency Projects

Water and energy efficiency programs and projects have existed and have been put into practice for over thirty years. The projects reduce energy and indirectly reduce GHG emissions by improving the efficiency of systems and equipment in our homes and businesses. These types of projects include: pump and motor replacement, refrigerator and hot water heater replacement, and water conservation programs. These types of projects are well understood, have well-established program procedures, and have demonstrated energy savings.

The project eligibility criteria for water and energy efficiency programs and projects have been developed by the US Department of Energy, state agencies, and local utilities and are often administered through the local utility. For example, PG&E has well-defined rebate programs with eligibility criteria for water and energy efficiency projects such as refrigerator replacement projects. A similar GHG reduction project developed by the Partners would need to supplement existing programs and accelerate the replacement of equipment to add additional energy savings, but otherwise would follow the established program guidelines of the PG&E rebate programs.

6.2.2 Renewable Energy Projects

Renewable energy projects, such as solar, wind, and new hydroelectric, generate energy without the use of fossil fuels. Micro-turbines and fuel cells that use bio-fuels or bio-methane, captured from landfills, dairies, or wastewater treatment plants (WWTPs) using food waste, can produce energy and reduce GHG emissions. Although some renewable technologies are still emerging, many types have been utilized for many years and are well understood and have demonstrated renewable energy production and indirect GHG reductions.

The project eligibility criteria for renewable energy projects have been developed by the US Department of Energy and state agencies. For example, the California Energy Commission (CEC) Emerging Renewables Program has defined eligibility criteria for renewable energy projects such as solar and wind projects. Any similar GHG reduction project developed by the Partners would need to provide new, additional renewable energy, but otherwise would follow the eligibility requirements for already established renewable projects.

6.2.3 GHG Offset Projects

GHG Offset projects are relatively new and are being developed to respond to efforts to address climate change. GHG Offset projects directly reduce GHG emissions by reducing the amount of fuel consumed, eliminating refrigerant GHGs, or by sequestering GHGs. Examples of GHG offset projects include: reductions in the use of fleet vehicle fuel; truck stop electrification that permits trucks to stop idling; cooling system monitoring and maintenance programs to reduce chlorofluorocarbon (CFC) and perfluorocompound (PFC) releases; and carbon sequestration in forests or wetlands.

Unlike energy efficiency and renewables projects, GHG Offset projects are relatively new. Guidelines have been developed to define eligibility criteria that each offset project must meet in order for it to be considered a regulatory compliance offset. The GHG Offset project eligibility criteria (specified in AB 32) include the following requirements:

- Additional
- Quantifiable
- Enforceable
- Real
- Permanent
- Verifiable

Project eligibility means that a project meets regulatory compliance (or eligibility) standards such that the reduction project could potentially qualify for a future GHG cap and trade system. In general, the same eligibility criteria also are required in the voluntary GHG market. For the BARDP, although it is not expected that potential GHG reduction projects would be traded in the marketplace, it is recommended that each offset be treated as if it were going to qualify as a regulatory compliance offset and meet the established eligibility requirements. Any third-party offset purchased from the voluntary GHG market would need to meet regulatory compliance eligibility standards.

6.3 Potential GHG Reduction Projects

A group of potential GHG reduction projects that could be used by the BARDP was developed based on Kennedy/Jenks' past project experience, and with input from the Partners. These projects have been shown to be cost-effective for other California desalination projects and for California water utilities looking to reduce energy use and associated GHGs.

For each potential GHG reduction project, the following sections provide a short description, the assumptions made when estimating the potential GHG reductions and unit costs, and the key considerations for further assessment. To further understand the specific costs and amount of GHG reductions for the BARDP, detailed project assessments will have to be conducted for each project, considering Partner-specific details.

For this phase of the BARDP project, the following analysis shows that the Partners can meet the potential GHG reduction goals with a set of feasible and cost-effective GHG reduction projects. The programs assessed for the BARDP as part of this study are:

- Additional Energy/Water Conservation (Washing Machine Rebates)
- Commercial/Residential Rebates (Solar Hot Water Heater Program)
- Energy Audits at Local WTPs and WWTPs
- Pump Efficiency Improvement Program
- Pump Energy Optimization Program (EOP)
- Green Building Design
- Commercial/Residential Renewables Rebates (Solar PV Program)
- FOG and Food Waste to Energy
- Invest in Large-Scale Renewable Energy Projects (e.g., Direct Access PPA)
- Local Solar PV Projects
- REC Purchases
- Recovered CO_2 Addition for Post-Treatment
- Fleet Fuel Reduction
- Wetlands Restoration
- GHG Offset Purchases

6.3.1 Additional Energy/Water Conservation

The Partners already implement water conservation programs as part of their overall water management plans to maximize water savings and incorporate the latest technologies and practices. Partner programs are developed to ensure compliance with state requirements, most recently the California Water Conservation Act of 2009 (or SBx7-7) demand reduction goals. An additional energy/water conservation project for the BARDP would build on existing activity by developing additional or accelerated programs to promote the reduction of energy and potable water use and to offset the associated GHG emissions.

A washing machine rebate program, for example, is effective at reducing energy and would provide rebates to residential and commercial customers throughout the Partner service areas to replace less efficient machines with more efficient machines. High-efficiency clothes washers (HEW) deliver high level wash performance while saving both water and energy. Resource efficient models use 35 to 50 percent less water and approximately 50 percent less energy than standard washing machines.

The effectiveness of this program would depend upon the success of any existing programs, the number of customers estimated to sign up per year, the rebate amount, and the energy use of the water that is offset (which will vary by Partner). For example, for the Santa Cruz area, it was assumed that about 440 customers (combined residential and commercial) would sign up per year over the course of 12 years. This would save approximately 450 MT CO_2e per year at a unit cost of between \$460 and \$600 per MT CO_2e, or approximately \$200 per AF. Depending on the Partner-specific programs and service areas, there is potential to achieve similar or more energy reduction through this type of program.

Note that because of the additionality requirements for these types of programs, the lifetime of the GHG reduction attributes for this project are assumed to last for the life of the HEWs (approximately 12 years). This is because of the assumption that as old washing machines break, they would naturally be replaced by higher efficiency machines. The additionality of the program comes from accelerating the replacement.

Key considerations for BARDP include:

- Are there existing programs in the BARDP service areas? What is the potential for an additional or accelerated program?
- Amount of GHG reduction relies on customer participation
- Program could be structured to be financed by local banks to reduce cost to Partners

6.3.2 Commercial/Residential Efficiency Rebates

A residential and/or commercial renewable energy rebate program would provide homeowners and businesses in the Partner service area with rebates or incentives to install renewable energy systems, such as solar water heater (SWH) systems. The electricity savings would be recognized by the SWH owners, but BARDP would purchase the associated GHG reduction credits. A program that could be considered is a SWH Group Buy Program, in which BARDP would work with local financial institutions and SWH providers to lower the cost of purchasing a

SWH system by doing a bulk purchase. This program would use local financial institutions to make the loans and would not require BARDP capital. In addition, the loan would eliminate one of the customers' key hurdles to purchasing SWH projects – the lack of up-front capital.

The BARDP role would be limited to facilitating and advertising the program and providing a modest rebate to secure the rights to the GHG emissions. As part of participation in the program individuals and businesses would be required to contractually sign over the right to the GHG emissions reductions from their system so that they could be claimed solely by BARDP, thereby avoiding double-counting. However, all the tax credits and energy production would remain with the system owner.

If 100 SWH systems were installed per year for a 5 year period, the program would reduce approximately 140 MT CO_2e per year. Assuming that rebates are financed by the local financial institution, the cost to the BARDP would be minimal and is estimated to be less than $1 per MT CO_2e and less than $1 per AF.

Key considerations for BARDP include:

- Are there existing programs in the BARDP service areas? What is the potential for an additional or accelerated program? How would recent advertisement and promotion of solar water heater system rebates in the Bay Area impact additionality?
- Amount of GHG reduction relies on customer participation
- Program easily could be expanded if customer interest is greater than anticipated
- Program could be structured to be financed by local banks to reduce cost to Partners

6.3.3 Energy Audits at Local WTPs and WWTPs

Audits to identify efficient energy equipment replacements and process improvement at a Partner's WTP or WWTP would include evaluating existing equipment and operations of the facility and identifying opportunities to make the facility more efficient. The type, magnitude, and cost of the project would greatly vary based on the existing facility conditions.

Table 6-1 provides examples from the Irvine Ranch Water District and City of Santa Cruz WWTP energy audits. Although these situations are specific to the respective agencies, they do demonstrate that there can be GHG reduction opportunities, as well as the ancillary benefit of providing significant reductions in facility operating costs.

Table 6-1 Potential GHG Reduction Goals

Agency Examples	Energy Savings (kWh/yr)	Annual GHG (MT CO2e/yr)	Unit Cost ($/MT CO_2e)	Unit Cost ($/AF)
Irvine Ranch Water District - Replace existing first generation T8 fluorescent fixtures with latest generation - Replace MR16 fluorescent fixtures with LED screw-in lamps - Shut off compressor at the Cl2 basin - Install a jockey pump on the in-plant water system - Program existing SCADA system to reduce energy demand - Decrease aeration in pond and install DO control - Install Energy Management System (EMS) software to optimization energy use	513,000	150	-$260	-$100
City of Santa Cruz WWTP - Install VFD on Carbon Scrubber Fans - Install a New VFD Air Compressor in Place of the Grit and DAFT Compressors - Replace One Centrifugal Dewatering Unit with a Screw Press Dewatering Unit - Replace the Standard Efficiency Lighting with High Efficiency Lighting - Install Lighting Control in Various Areas - Replace Aeration Blower #1 with a High Efficiency Turbo Blower - Replace one of the Interstage Pumps with a VFD Controlled Pump, and Use the Smaller Interstage Pump as Backup	1,100,000	330	-$215	-$80

Key considerations for BARDP include:

- Project may have a ongoing net cost savings to Partner Agencies and lower operating costs
- Amount of GHG reduction and cost will depend on existing facility conditions
- What plants in the Partner Agencies service area might be considered?
- Plant staff can be resistant to operational/process changes
- Energy savings must be done specifically for the BARDP project to meet additionality eligibility requirement

6.3.4 Pump Efficiency Improvement Program

A pump efficiency improvement program would evaluate all pumps in a Partner's water system and would install cost-effective pump retrofits at an accelerated pace, such as over a 1 year period instead of over a more typical 15 year period. This program would only count the GHG reduction associated with the acceleration of the pump replacement program. For example, assuming that that pumps are replaced on average every 15 years through routine maintenance, an inefficient pump that is 6 years old would continue to run at an inefficient rate for another 9 years, wasting energy and creating additional GHG for those 9 years. If this pump were replaced, the energy savings and associated GHG reductions could only be counted as a GHG reduction project for the 9 remaining years of that pump's life.

The cost effectiveness of this program is very much dependent upon the existing system efficiency and the power cost. For Irvine Ranch Water District's extensive water pumping system, the estimated annual GHG reduction was approximately 640 MT CO_2e per year at a unit cost savings of$150 per MT CO_2e (or a savings of approximately $60 per AF). For the Soquel Creek Water District's relatively small groundwater pumping system, however, the estimated annual GHG reduction was 30 MT CO_2e per year at a unit cost of over $900 per MT CO_2e (or approximately $360 per AF for BARDP). Since this project does have the potential to be extremely cost-effective, Kennedy/Jenks recommends further analysis of this potential project in future studies.

Key considerations for BARDP include:

- Project may have a net cost savings to Partner Agencies, thus lowering operating costs
- Amount of GHG reduction and cost will depend on existing facility conditions

6.3.5 Pump Energy Optimization Program

A water pump Energy Optimization Program (EOP) would increase water system energy efficiency and reduce associated GHG reductions by: 1) preferentially using the most efficient pumps within the water delivery system and 2) adjusting system conditions such that pumps in operation are as close to their highest efficiency points as possible. Pump scheduling commonly associated with EOP's can significantly save energy and reduce electricity costs by optimizing use of water storage within the system to minimize pumping done during higher cost time-of-use (TOU) rate periods of the day.

EOP's can vary in degree of complexity. At the most basic level, they can simply entail manual decision making in terms of pump selection and time of pumping. The next level of sophistication would be the use of water distribution modeling programs to run various "what if" scenarios that would suggest general operating schemes to reduce energy use/cost. The most complex EOP's are real-time predictive software programs that are tied directly to a water system's Supervisory Control and Data Acquisition (SCADA) system, such as the Derceto system run by EBMUD.

The amount of electricity savings and the associated GHG reduction will depend on the existing conditions of the BARDP Partners' systems. The cost effectiveness of this type of project is dependent upon the amount of actual savings. For example, the estimate for IRWD was that if 2 percent pump energy savings were achieved, it would reduce GHG emissions by 200 MT CO_2e per year at a unit cost of $460 per MT CO_2e (or approximately $170 per AF for BARDP). If 4 percent were achieved, the GHG emissions reduction doubled to 400 MT CO_2e and the unit cost substantially decreased to $50 per MT CO_2e (or approximately $20 per AF for BARDP).

Key considerations for BARDP include:

- Are existing EOP programs in place (other than at EBMUD)?
- What is the capital and implementation cost associated with these software programs?
- Cost-effectiveness is dependent on the amount of actual savings; at the low end of the savings range the project is not cost-effective and the upper end of the range the project is cost-effective.
- Amount of GHG reduction and cost will depend on existing facility conditions
- Potential for resistance and distrust of scheduling recommendations made by EOP software.

6.3.6 Green Building Design

A green building design project would incorporate sustainable, efficient design strategies directly into the BARDP facility. The Partners could pursue LEED (or Leadership in Energy and Environmental Design) or an equivalent certification for the BARDP Desalination Facility. These types of programs require that a building meet energy and sustainability standards by choosing to implement measures from a comprehensive list of potential efficiency measures.

The LEED standard requires implementation of measures from the following categories: human and environmental health, sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. Some of the green building concepts incorporated into LEED certification include (USGBC, 2008):

- Sustainable Sites
    - Protect or restore habitat
    - Minimize or treat stormwater runoff
    - Build facility near public transportation or install bicycle storage for employees
- Water Efficiency
    - Minimize building water use
    - Plant water-efficient landscaping
    - Install innovative wastewater or recycled water treatment technologies
- Energy and Atmosphere
    - Optimize energy performance of building
    - Manage refrigerants
    - Utilize on-site renewable energy or purchase green power

- Materials and Resources
    - Utilize reused or recycled materials
    - Manage and minimize construction waste
    - Use local materials
    - Install rapidly renewable materials
- Indoor Environmental Quality
    - Meet standards for air quality performance and monitoring
    - Install system to increase ventilation
    - Use low-emitting materials, such as paints, sealants, flooring systems, composite wood
    - Include lighting and heating controls
    - Design office spaces to increase daylight

Note that not all of the LEED measures will reduce energy use or GHG emissions.

Based on information from a GHG study conducted for the proposed Carlsbad desalination project (Voutchkov, 2008) and included in its Energy Plan, a similar green building design is estimated to reduce the indirect GHG emissions for the BARDP by approximately 30 to 50 MT CO_2e per year. The cost could range from approximately $3,000 to $5,000 per MT CO_2e or approximately $1,100 to $1,900 per AF for BARDP.

Key considerations include:

- Reduces onsite energy use of the facility and will lower the energy factor of the BARDP Desalination Facility production component of the overall desalination supply energy.

6.3.7 Commercial/Residential Renewables Rebates

A residential and/or commercial renewables rebate program could provide homeowners and businesses in the Partner service areas with rebates or incentives to install solar photovoltaic (solar PV) systems. The electricity savings would be recognized by the PV system owners, but BARDP contractually could own the associated GHG reduction credits. Similar to the SWH rebate program described in Section 5.2.2, a program that could be considered is a Solar PV Group Buy Program, in which BARDP would work with local financial institutions and solar PV providers to lower the cost of purchasing a solar PV system by doing a bulk purchase. This program could use local financial institutions to make the loans and would not require BARDP capital. In addition, the loan would eliminate one of the customers' key hurdles to purchasing solar PV projects – the lack of up-front capital.

The BARDP role would be limited to facilitating and advertising the program and providing a modest rebate to secure the rights to the GHG emissions. As part of participation in the program, individuals and businesses would be required to contractually sign over the right to the GHG emissions reductions from their systems so that they could be claimed solely by BARDP, thereby avoid being double counted. However, all the tax credits and energy production would remain with the system owner.

If 100 solar PV systems were installed per year for a 5 year period, the program would reduce approximately 150 MT CO_2e per year. Assuming that rebates are financed by the local financial institution, the cost to the BARDP would be minimal and is estimated to be less than $1 per MT CO_2e and less than $1 per AF.

Key considerations for BARDP include:

- Are there existing programs in the BARDP service area? What is the potential for an additional or accelerated program? PG&E already provides solar rebates to customers and demonstrating additionality may be difficult.
- Amount of GHG reduction relies on customer participation
- Program easily could be expanded if customer interest is greater than anticipated
- Program could be structured to be financed by local banks to reduce cost to Partners

6.3.8 FOG and Food Waste to Energy

A fats, oils and grease (FOG) and food waste to energy (FWTE) project combines organic waste from foods with wastewater solids in a wastewater anaerobic digester to produce additional biogas. According to the US EPA, food waste produces approximately three times the amount of biogas compared to wastewater solids. A FWTE study conducted for the Santa Cruz and Soquel Creek Water District (**scwd**^{2}) Desalination Program by Kennedy/Jenks estimated an average annual GHG reduction of approximately 800 MT CO_2e per year at a unit cost of approximately $280 per MT CO_2e (or approximately $100 per AF for BARDP). This amount and cost is project-specific and would have to be further investigated for BARDP. EBMUD has an existing FWTE program, so the potential to expand this project or explore new opportunities at other Partner facilities will have to be investigated further.

Key considerations include:

- Is there any available capacity at EBMUD facility for an additional project?
- Is there potential for opportunities at other local WWTPs?

6.3.9 Invest in Large-Scale Renewable Energy Projects

Investing in large-scale renewable energy projects to serve the Partners’ electricity load, instead of purchasing electricity from PG&E (which includes energy produced from fossil fuels), would provide GHG reduction. Renewable energy technologies include solar PV, wind turbines, solar thermal, geothermal, biomass, and fuel cells.

A renewable energy purchase program can be developed through a number of avenues. Various options include:

- *Collaboration through a JPA:* A joint powers authority (JPA) is an entity made up of several public agencies that owns and operates renewable energy projects through a joint equity purchase. BARDP would share risk and responsibility of owning the project with other members of the JPA. A higher level of management participation also would be required for equity partnership in a JPA. While terms of specific contracts vary, equity partners share the responsibility for the installation to meet performance requirements, and therefore they tend to participate in the decision-making and other aspects of the O&M of the installation.

- *Direct Access Power Purchase Agreement (PPA):* BARDP could purchase renewable energy through a direct access PPA, in which electricity and associated GHG reduction credits from a renewable energy project developed by a third party would be sold to BARDP for a contracted price and specified duration of time. Examples could include large-scale (approximately 10 to 250 MW) wind, solar, and hydropower projects.

- *Collaboration through a CCA:* A community choice aggregation (CCA) is an entity or group of entities, such as a city or county or both, that purchases and/or generates electricity and sells it to the local community. CCAs allow communities to increase the amount of renewable energy in the portfolio. PG&E would continue to delivery electricity through the grid and provide billing and customer services. Marin currently is operating a CCA.

This approach to GHG reductions has the ability to meet 100 percent of the BARDP GHG reduction goals. Depending upon the avenue and type of renewable project, the program is estimated to cost approximately \$60 to \$100 per MT CO_2e, or \$20 to \$40 per AF of desalinated water produced.

6.3.10 Local Solar PV Projects

A local solar program would entail installing solar photovoltaic (PV) panels on Partner properties to provide an emissions-free renewable energy source that reduces the use of grid electricity and the associated indirect GHG emissions. Depending upon the extent of the local solar project and the availability of land, this project has the potential to reduce 100 percent of the BARDP carbon footprint. This program is estimated to cost approximately \$830 per MT CO_2e or \$310 per AF of desalinated water produced.

This cost is based on the following assumptions:

- 1,400 kWh/year per kW installed or approximately 14 kWh/year per square foot
- \$6 per Watt installed
- 0.75% annual PV degradation impact
- No state or federal incentives
- PG&E planning emissions factor of 290 pounds CO_2e per MWh

Approximately 130 acres would be required to reduce approximately 9,200 MT CO_2e per year.

Key considerations include:

- Availability of rooftops or land parcels that are large enough with adequate sun exposure
- Availability of grid capacity to accept large solar PV projects

6.3.11 REC Purchases

To offset the indirect GHG emissions of the BARDP facility, the Partners could purchase certified renewable energy credits (RECs). RECs are tradable, non-tangible energy commodities that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource. RECs represent the environmental attributes of the electricity produced and are sold separately from commodity electricity. For example, BARDP could buy RECs from a wind farm in southern California, which would include the associated GHG reductions from displacing grid electricity. The RECs would have to be registered to ensure that no one else is claiming the environmental benefits, thus preventing double-counting.

This approach to GHG reduction has the ability to meet 100 percent of the BARDP GHG reduction goals. As of 2012, RECs are approximately \$0.02 per kWh or approximately \$20 per MT CO_2e. This would equal approximately \$6 per AF for BARDP.

Key considerations for BARDP include:

- Easy to purchase
- Flexible purchasing of RECs makes them useful in annual "true-up" process.
- The general public does not understand how RECs are certified and often question whether RECs are real and permanent. BARDP may need to do public education about the rigor that RECs go through before pursuing this option for more than a small percentage of GHG reduction.

6.3.12 Recovered CO_2 Addition for Post-treatment

Desalination RO permeate requires post-treatment, including corrosion control, to stabilize the water before releasing it into the potable water distribution system. Various chemicals can be used in this process, including carbon dioxide (CO_2). To create a GHG reduction project, BARDP could purchase CO_2 from a facility that recovers and purifies the CO_2 from the waste streams of industrial production facilities that would otherwise be released to the atmosphere, therefore offsetting direct GHG emissions. The recovered CO_2 would be National Sanitation Foundation (NSF) certified, food grade CO_2 that is produced locally in the SF Bay Area. This type of GHG Offset is being used for the Carlsbad Desalination Project in Carlsbad, CA.

Assuming the BARDP facility would use approximately 250 pounds of CO_2 per million gallons of water treated, a CO_2 addition project is estimated to offset approximately 600 MT CO_2 per year for the total project. This project could reduce approximately 9 percent of the facility carbon footprint.

Because the carbon dioxide system would be a part of the BARDP Desalination Facility, there is no additional capital cost to implement this GHG reduction project. Not including minor administrative costs to track the CO_2 and GHG reduction, the cost effectiveness is high and estimated to be \$0 per MT CO_2 and \$0 per AF.

6.3.13 Fleet Fuel Reduction

A fleet fuel reduction program would change the composition of the Partners' vehicle fleets, use alternative vehicles and fuels to reduce the GHG emissions of the fleets. The amount of GHG reduction and cost effectiveness of this program is dependent upon the makeup of the existing vehicle fleets and the extent of implementation of the fleet fuel reduction program.

As an example, the potential GHG reduction program for the **scwd^2** Desalination Program include replacing approximately 80 fleet vehicles, utilizing B-20 biodiesel fuel, and implementing driver behavioral changes. These changes were estimated to reduce approximately 55 MT CO_2 per year at a cost of over $7,000 per MT (or almost $3,000 per AF for BARDP).

Key considerations for BARDP include:

- Are there existing fleet fuel reduction programs? What is potential for additional or accelerated program?
- Some of the significant costs are associated with the purchase cost of new vehicles and installation of infrastructure.

6.3.14 Wetlands Restoration

A wetlands restoration project would entail restoring local wetland habitat that consumes CO_2 directly from the atmosphere to be used by plants or stored in wetland soil. A GHG study conducted for the proposed Carlsbad desalination project estimated that a 34-acre tidal wetland could sequester approximately 304 MT CO_2e per year, which equates to approximately 9 MT CO_2e per year per acre. As an example, if BARDP were to restore 100 acres of wetlands, the project could sequester approximately 900 MT CO_2e annually. This is estimated to cost approximately $400 per MT CO_2e or approximately $100 per AF for BARDP. (Voutchkov, 2008)

Key considerations for BARDP include:

- Can be difficult to quantify GHG reduction and may not meet all the requirements for a certified offset project
- May want to consider these types of projects because of the public outreach benefits

6.3.15 GHG Offset Purchases

A GHG offset purchase program would entail purchasing certified GHG offset projects that gives BARDP the sole legal right to claim the GHG emission reductions from the project. There are a number of different types of GHG offset including: direct reductions of the use of fossil fuels; methane capture at landfills, dairies, or WWTPs; or reforestation projects. One GHG offset represents a reduction of one MT CO_2e. In the offset market place BARDP could buy as many GHG offsets as needed to meet their GHG reduction goals.

GHG offset costs vary depending on the type and source of the offset. This assessment assumes that BARDP would purchase only certified offsets. The voluntary offset market prices for currently range from $10 to $20/MT; this analysis assumes that the price of offsets for the

BARDP would be approximately $20/MT, or approximately $6 per AF of BARDP desalinated water produced. These costs are expected to increase over time.

Key considerations for BARDP include:

- Easy to purchase
- Flexible purchasing of GHG offsets makes them useful in annual "true-up" process.
- The general public does not understand how GHG offsets are certified and often question whether offsets are real and permanent. BARDP may need to do public education about the rigor that offsets go through before pursuing this option for more than a small percentage of GHG reduction.

6.3.16 Summary of Potential Projects

Table 6-2 summarizes the conceptual and approximate GHG reduction amounts and costs of potential GHG reduction projects for the BARDP.

Table 6-2 Potential GHG Reduction Projects

Project	Estimated Annual GHG Reduction (MT CO_2e/year)[1,2]	Estimated GHG Unit Cost (\$/MT CO_2e)[1,2]	Estimated Additional Water Unit Cost (\$/AF)[1,2]
Additional Energy/Water Conservation (e.g., Washing Machine Rebates)	450	\$460 to \$600+	\$170+
Commercial/Residential Rebates (Solar Hot Water Heater Program)	140	< \$1	< \$1
Process Energy Audit at Local WTPs and WWTPs	150 to 330	-\$260 to -\$215	-\$100 to -\$80
Pump Efficiency Improvement Program	30 to 640	-\$150 to \$820	-\$60 to \$360
Pump Energy Optimization Program (EOP)	200 to 400	\$50 to \$460	\$20 to \$170
Green Building Design	30 to 50	\$3,000 to \$5,000	\$1,100 to \$1,900
Commercial/Residential Rebates (Solar PV Program)	150	< \$1	< \$1
FOG and Food Waste to Energy	800	\$280	\$100
Invest in Large-Scale Renewable Energy (e.g., Direct Access PPA)	± 9,200[3]	\$60	\$20
Local Solar PV Projects	± 9,200[3]	\$830	\$310
REC Purchases	± 9,200[3]	\$20	\$6
Recovered CO_2 Addition for Post-Treatment	600	\$0	\$0
Fleet Fuel Reduction	55	\$7,700	\$2,800
Wetlands Restoration	± 900[3]	\$400	\$100
GHG Offset Purchases	± 9,200[3]	\$20	\$6

Notes:

[1] The GHG reduction amounts and costs are approximate order of magnitude values to provide relative comparison to future analysis by the BARDP.

[2] Additional Partner-specific analyses are required to confirm the GHG reduction amounts and costs for the various GHG reduction programs and projects.

[3] This project is flexible and could be expanded to offset up to 100% of the project footprint. Other projects would be limited by outside factors, such as public participation or maximum efficiencies.

Other details that affect a GHG reduction project cost estimate include each agency's average utility energy cost (\$/kWh), cost per full-time equivalent (FTE), utilization of cash versus borrowing, and loan/bond rate. These details will need to be investigated in future work to confirm the cost-effectiveness of potential GHG reduction projects.

6.4 Example Project Portfolios

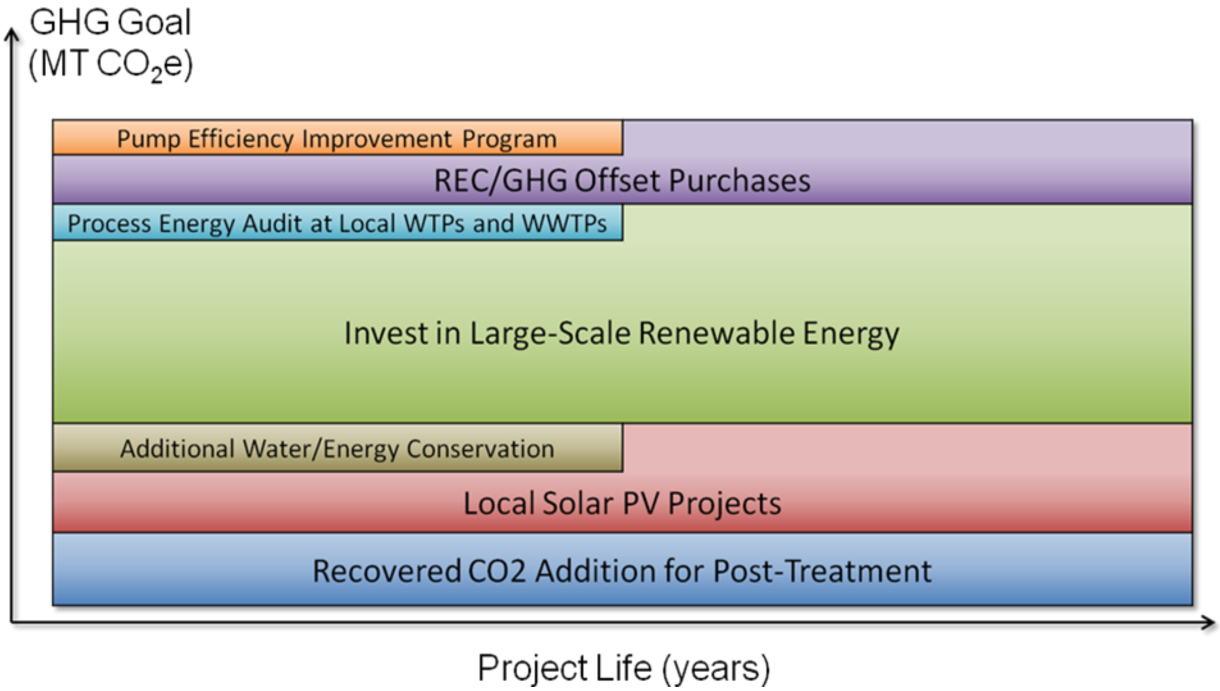
To build a GHG reduction project portfolio for BARDP, numerous iterations of groups of projects and associated GHG reduction amounts could be assembled to meet the GHG reduction goal. Although specific project portfolios cannot be developed at this time without further project assessment, the following tables and figure show two conceptual examples of what a project portfolio could include to meet a No Net Increase in Water Portfolio goal.

Table 6-3 and Figure 6-1 show an example project portfolio assembled using local projects and a diversified approach. This example portfolio is estimated to have a total cost of approximately $1.1 million per year and a unit cost of approximately $50 per AF of desalinated water produced.

Table 6-3 Example Project Portfolio – Local, Diversified Approach

Project	Estimated Annual GHG Reduction (MT CO_2e/year)	Estimated GHG Unit Cost ($/MT CO_2e)	Total Annual Project Cost ($/yr)
Recovered CO_2 Addition for Post-Treatment	600	$0	$0
Local Solar PV Projects	1,000	$830	$830,000
Invest in Large-Scale Renewable Energy (e.g., Direct Access PPA)	2,600	$60	$156,000
Additional Water/Energy Conservation (e.g., Washing Machine Rebates)	400	$600	$240,000
REC/GHG Offset Purchases	400	$20	$8,000
Process Energy Audit at Local WTPs and WWTPs	300	-$215	-$64,500
Pump Efficiency Improvement Program	200	-$150	-$30,000
Total (to meet No Net Increase in Water Portfolio)	**5,500**	**$260**	**$1,139,500**
		Unit Cost ($/AF)	**$50**

Figure 6-1 Example GHG Reduction Project Portfolio



Tables 6-4 and 6-5 show a second example project portfolio that employs a simple, low-cost approach to meet both the No Net Increase and Carbon free Desalinated Water goals. These example portfolio would rely more on investing in large scale renewable projects and offsets to reduce the costs of meeting the goals.

Table 6-4 Example Project Portfolio – Simple, Low-Cost Approach for No Net Increase Goal

Project	Estimated Annual GHG Reduction (MT CO_2e/year)	Estimated GHG Unit Cost ($/MT CO_2e)	Total Annual Project Cost ($/yr)
Recovered CO_2 Addition for Post-Treatment	600	$0	$0
Invest in Large-Scale Renewable Energy (e.g., Direct Access PPA)	4,100	$60	$246,000
REC/GHG Offset Purchases	500	$20	$10,000
Process Energy Audit at Local WTPs and WWTPs	300	-$215	-$64,500
Total (to meet No Net Increase in Water Portfolio)	**5,500**	**$30**	**$191,500**
		Unit Cost ($/AF)	**$10**

Table 6-5 Example Project Portfolio – Simple, Low-Cost Approach for Carbon Free Desalinated Water Goal

Project	**Estimated Annual GHG Reduction (MT CO_2e/year)**	**Estimated GHG Unit Cost ($/MT CO_2e)**	**Total Annual Project Cost ($/yr)**
Recovered CO_2 Addition for Post-Treatment	600	$0	$0
Invest in Large-Scale Renewable Energy (e.g., Direct Access PPA)	7,800	$60	$468,000
REC/GHG Offset Purchases	500	$20	$10,000
Process Energy Audit at Local WTPs and WWTPs	300	-$215	-$64,500
Total to meet Carbon Fee Desalinated Water Goal	**9,200**	**$30**	**$413,500**
		Unit Cost ($/AF)	**$20**

Next steps in the Energy Plan development will include additional evaluation of project portfolios to identify options to meet the needs and objections of the BARDP and each of the Partners.

Section 7: Conclusion

7.1 Summary

The energy requirement of desalination is among the key issues in the evaluation of the BARDP. In line with their environmental stewardship principles, the Partners are committed to reducing the energy use and carbon footprint of the proposed BARDP.

As described in Section 2.1, the future BARDP EIR will identify the appropriate GHG TOS for the project under CEQA and will provide the substantial evidence required to support that threshold. Depending upon their goals, the Partners either could choose to meet the regulatory requirement of the BARDP TOS or could opt to exceed the regulatory requirement by selecting a greater level of GHG reduction. The amount of GHG reduction for the Partners will depend upon the GHG reduction goal selected.

7.1.1 Potential GHG Reduction Amounts

Table 7-1 shows the estimated annual indirect GHG emissions for the Partners to reduce, averaged over the thirty-year projection period to meet two potential GHG reduction goals. The actual annual GHG emission reduction amounts would vary based on actual water use and associated emissions for a given year.

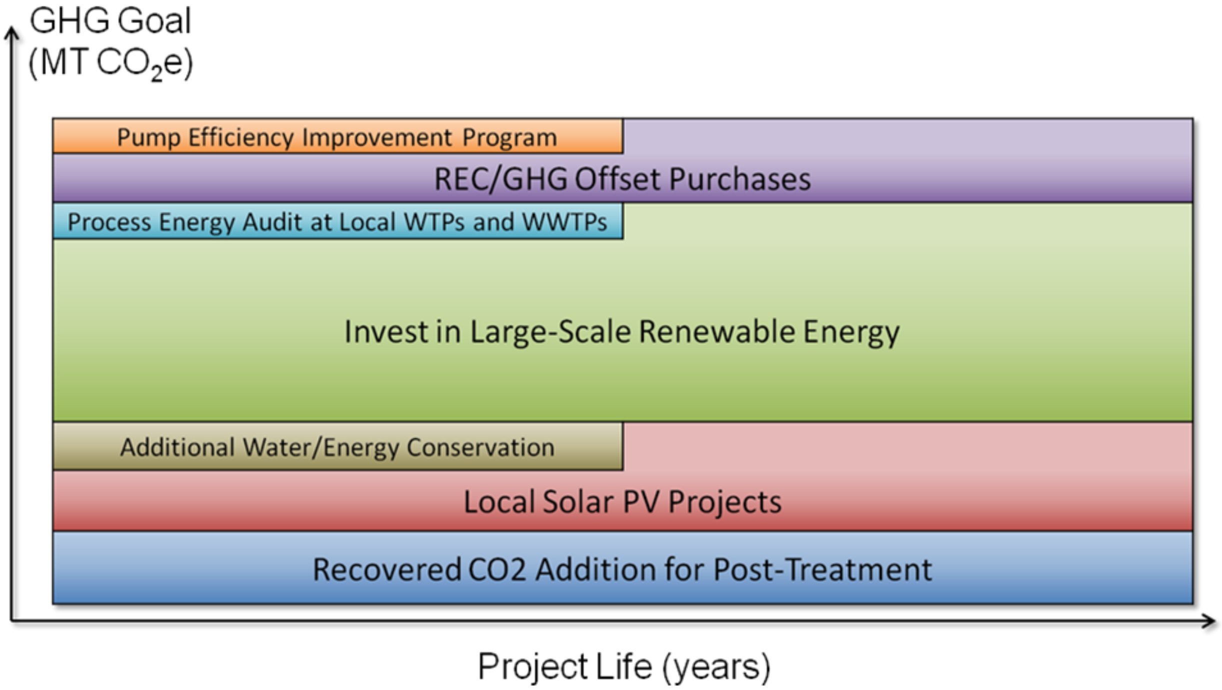
Table 7-1 Summary of Potential GHG Reduction Goals

Partner	No Net Increase in Water Portfolio (MT CO_2e/year)	Carbon-Free Desalinated Water Supply (MT CO_2e/year)
CCWD	180	470
EBMUD	50	1,060
SCVWD	230	1,070
SFPUC	4,280	4,280
Zone 7	1,070	2,360
Total	**5,810**	**9,240**

7.1.2 Estimated Cost of Potential GHG Reduction

The estimated costs for reducing the indirect GHGs from the BARDP will depend on the GHG reduction goal and on the approach and projects selected for the GHG reduction portfolio. Based on the conceptual level evaluation presented in Section 6, the costs could range from \$10 to \$50 per AF of desalinated water produced. Potential renewable energy and GHG reduction projects would be implemented and monitored over the life of the project, as shown in Figure 7.1, to meet the GHG reduction goals for the BARDP.

Figure 7-1 Example GHG Reduction Project Portfolio



7.2 Putting BARDP GHG Emissions into Perspective

The use of the BARDP could indirectly create on average up to approximately 9,200 MT CO_2e per year. These indirect GHG emissions are equivalent to the direct emissions from approximately 1,800 typical automobiles.

The indirect GHG emissions from the BARDP are relatively small when compared to other GHG emissions in the Bay Area. Those GHG emissions levels include:

- Bay Area carbon footprint of almost 96 million MT CO2e in 2007 (City of San Jose, 2011)
- City of San Francisco carbon footprint of 5.4 million MT CO2e in 2010 (City and County of San Francisco, 2011)
- City of Oakland carbon footprint of approximately 2 million MT CO2e in 2005 (City of Oakland, 2011)

7.3 Next Steps

The information developed in this GHG Analysis will be used in the next steps of the Energy Plan process to help the Partners evaluate GHG reduction projects and approaches to reach the selected goals. Next steps include:

- Conduct detailed analyses of renewable energy, energy efficiency, and GHG reduction projects and options
- Select agency-specific GHG reduction goals through CEQA process
- Prepare an Energy Plan to meet the goals of the BARDP

Potential renewable energy and GHG reduction projects would be evaluated for cost, amount of GHGs produced or saved, technical maturity and reliability, operational impacts, and environmental and community impacts. The top ranking alternatives could then form the elements of the Project Energy Plan.

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Appendix A

Detailed Process Unit Energy Calculations

Bay Area Regional Supplemental Water Supply Project
Greenhouse Gas Analysis
Example Energy Calculation Summary (January)

Table 1. BARSWSP 2-Stage BWRO/SWRO Energy Calculations (14.5MGD. Salinity varies by Month. See Pilot Report Appendix H for BWRO/SWRO Energy vs Salinity.)

Description	Number (#)	Qty Online (#)	Pump Eff (%)	Specific Gravity (#)	Motor Eff. (%)	Flow (gpm)	TDH (ft)	Brake Motor (HP)	Installed Motor (HP)	VFD Eff (%)	Power (kW)	Online Factor (%)	Power Cons. (kWh/yr)	kWh/kgal	kWh/m^3	Rank	Total (kWh/kgal)
INTAKE																	0.68
➤ Raw Water Pumps	3	2	75%	1.03	95%	8,367	115	334.8	355.0	98%	268.2	100%	4,698,200	0.68	0.18	2	
PRETREATMENT																	0.23
Rapid Mixer	2	1	-	-	-	-	-	-	1.0	-	0.7	100%	6,600	0.00	0.00	27	
100 Micron Screen	4	3	-	-	-	-	-	-	2.0	-	1.5	100%	39,200	0.01	0.00	13	
Other Systems																	
MF Cleaning Pump	2	1	75%	1	95%	2,456	25	20.7	25.0	-	16.2	5%	7,200	0.00	0.00	26	
MF Blowers	2	1	-	-	-	-	-	-	3.0	-	2.2	20%	4,000	0.00	0.00	28	
MF Compressors	2	1	-	-	-	-	-	-	1.0	-	0.7	20%	1,400	0.00	0.00	34	
MF BW Pump	2	1	75%	1.03	95%	2,340	35	28.4	30.0	-	22.3	20%	39,100	0.01	0.00	14	
MF CIP Heater	2	1	-	-	-	-	-	-	-	-	563.0	2%	98,700	0.01	0.00	10	
MF Neutralized Chemical Transfer Pump	2	1	75%	1.03	95%	260	20	1.8	2.0	-	1.4	1%	200	0.00	0.00	38	
Residuals																	
Equalization Well Clarifier Pumps	3	2	75%	1.03	95%	1,314	35	15.9	20.0	98%	12.8	100%	223,900	0.03	0.01	7	
Clarifier Sludge Thickener Drive	2	2	-	-	-	-	-	-	7.5	-	5.6	100%	98,000	0.01	0.00	11	
Decant Recycle Pumps (Active)	3	2	75%	1.03	95%	1,183	105	43.2	48.0	98%	34.6	100%	606,600	0.09	0.02		
Centrifuge Feed Pumps	2	1	40%	1.03	95%	552	231	82.8	90.0	98%	66.3	33%	193,700	0.03	0.01	9	
Centrifuges	2	1	-	-	-	-	-	-	100.0	-	74.6	33%	217,800	0.03	0.01	8	
Centrifuge Conveyor	2	1	-	-	-	-	-	-	7.5	-	5.6	33%	16,400	0.00	0.00		
Centrifuge Truck Conveyor	2	1	-	-	-	-	-	-	7.5	-	5.6	33%	16,400	0.00	0.00		
Chemicals																	
Metering Pumps	10	5	-	-	-	-	-	-	1.0	98%	0.8	100%	33,400	0.00	0.00	15	
Metering Pumps - Membrane Clean and Neut.	10	5	-	-	-	-	-	-	1.0	98%	0.8	5%	1,700	0.00	0.00	32	
DESALINATION																	4.03
➤ BWRO Booster Pump	3	2	80%	1.03	95%	8,235	115	308.9	330.0	98%	247.5	100%	4,335,400	0.63	0.17	3	
➤ BWRO High Pressure Pump	12	12	80%	1.03	95%	1,373	635	283.5	300.0	98%	227.1	100%	23,868,300	3.44	0.91	1	
➤ SWRO Interstage Pump	12	12	80%	1	95%	535	219	37.0	40.0	98%	29.7	100%	3,119,000	0.45	0.12	4	
➤ Energy Recovery Device	12	12	88%	1.05		273	815	-	-	-	-36.4	100%	-3,822,900	-0.55	-0.15	40	
Other Systems																	
RO CIP Pump	2	1	75%	1	95%	1,440	3	1.4	5.0	98%	1.1	2%	200	0.00	0.00	38	
RO Flush Pumps	2	1	75%	1	95%	1,400	3	1.3	5.0	-	3.7	2%	700	0.00	0.00	37	
RO CIP Tank Mixer	1	1	-	-	-	-	-	-	7.0	-	5.2	2%	1,000	0.00	0.00	35	
RO CIP Heater	2	2	-	-	-	-	-	-	-	-	198.0	2%	69,400	0.01	0.00	12	
RO Neutralization Pumps	2	1	75%	1.03	95%	5,690	70	138.1	150.0	-	108.4	2%	19,000	0.00	0.00	20	
Brine Disposal Pumps	3	2	75%	1.05	95%	1,756	40	24.8	30.0	98%	19.9	100%	348,600	0.05	0.01	6	
Chemicals																	
Metering Pumps	4	2	-	-	-	-	-	-	1.0	98%	0.8	100%	13,400	0.00	0.00	24	
Metering Pumps - RO Clean	6	3	-	-	-	-	-	-	1.0	98%	0.8	5%	1,000	0.00	0.00	35	
POST TREATMENT																	0.02
Chemicals																	
Metering Pumps	6	3	-	-	-	-	-	-	1.0	98%	0.8	100%	20,000	0.00	0.00	17	
CO2 System - solution pumps	2	1	70%	1	95%	44	150	2.4	3.0	-	1.9	100%	16,400	0.00	0.00	21	
CO2 System - refrigeration	2	2	-	-	-	-	-	-	2.0	-	1.5	100%	26,200	0.00	0.00		
CO2 System - vaporizer	2	1	-	-	-	-	-	-	0.5	-	0.4	100%	3,300	0.00	0.00		
Lime Feeder	2	1	-	-	-	-	-	-	3.0	98%	2.3	100%	20,000	0.00	0.00	17	
Lime Slurry Pumps	2	1	45%	1	95%	12	60	0.4	1.0	-	0.3	100%	2,700	0.00	0.00	30	
Lime Saturator Rake	1	1	-	-	-	-	-	-	3.0	98%	2.3	100%	20,000	0.00	0.00	17	
Lime Saturator Mixer	1	1	-	-	-	-	-	-	2.0	98%	1.5	100%	13,400	0.00	0.00	24	
Lime Inert Pumps	2	1	40%	1	90%	5	80	0.3	1.0	98%	0.2	100%	1,900	0.00	0.00	31	
Lime Water Pumps	2	1	70%	1	95%	11	60	0.2	0.5	-	0.2	100%	1,700	0.00	0.00	32	
MISCELLANEOUS																	0.25
HVAC (Included in Contingency)																	
Lights & Misc (Included in Contingency)																	
Contigency	5%												1,719,060	0.25	0.07		
																	5.21

BWRO = Brackish water reverse osmosis

CIP = Clean-in-place

MF = Microfiltration

RO = Reverse osmosis

SWRO = Seawater reverse osmosis

Appendix B

BARDP Water Supply Calculations

B.1 Desalination Water Supply Calculations

Assumptions:

Evaporation from Storage 3.75%

Table B-1 Theoretical Desalination Facility Operation (mgd)

Agency	Projected Annual Water Supply (mgd)																														Total Demand	# of Years	Frequency
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050			
CCWD	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	13	0	13	13	0	0	0	0	0	0	0	0	0	52	4	1/8
EBMUD	0	0	0	0	0	0	9	9	9	9	0	0	0	0	0	0	0	9	9	9	9	9	9	0	9	0	0	0	0	0	0	99	11	1/3
SCVWD	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	0	10	0	0	0	0	0	0	90	9	2/7
SFPUC	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	279	31	1
Zone 7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	155	31	1
Total Desalination Supply	**14**	**14**	**14**	**14**	**14**	**14**	**33**	**46**	**23**	**23**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**33**	**46**	**33**	**46**	**46**	**33**	**14**	**33**	**14**	**14**	**14**	**14**	**14**	**14**	**675**		

Table B-2 Projected Actual Desalination Facility Operation - Direct and Stored (mgd)

Agency	Projected Annual Water Supply (mgd)																															
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050		
Direct Use of Desalination Facility																																	
CCWD	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0		
EBMUD	0	0	0	0	0	0	2.8	1.7	6	6	0	0	0	0	0	0	0	2.8	1.7	2.8	1.7	1.7	2.8	0	2.8	0	0	0	0	0	0		
SCVWD	0	0	0	0	0	0	3.2	1.9	0	0	0	0	0	0	0	0	0	3.2	1.9	3.2	1.9	1.9	3.2	0	3.2	0	0	0	0	0	0		
SFPUC	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9		
Zone 7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		
Total Direct Use	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**		
To Storage																																	
CCWD[1]	1.4	1.4	1.4	1.4	1.4	1.4	0	0	0	0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0	0	0	0	0	0	1.4	0	1.4	1.4	1.4	1.4	1.4	1.4		
EBMUD[1]	2.2	2.2	2.2	2.2	2.2	2.2	0	0	0	0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	0	0	0	0	0	0	2.2	0	2.2	2.2	2.2	2.2	2.2	2.2		
SCVWD[1]	2.4	2.4	2.4	2.4	2.4	2.4	0	0	0	0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	0	0	0	0	0	0	2.4	0	2.4	2.4	2.4	2.4	2.4	2.4		
Total To Storage	**6**	**6**	**6**	**6**	**6**	**6**	**0**	**0**	**0**	**0**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**6**	**6**	**6**	**6**	**6**	**6**		
From Storage		0%	0%	0%	0%	0%	0%	25%	33%	33%	0%	0%	0%	0%	0%	0%	0%	0%	12%	68%	81%	81%	68%	0%	38%	0%	0%	0%	0%	0%	0%		
Total Storage Available	6	11	17	22	27	32	18	0	0	0	6	11	17	22	27	32	36	22	0	0	0	0	0	6	0	6	11	17	22	27	32	**mgd Storage Used**	**% Storage Use[1]**
CCWD	0	0	0	0	0	0	0	7.3	0	0	0	0	0	0	0	0	0	0.0	9.1	0	0	0	0	0	0.0	0	0	0	0	0	0	16	23%
EBMUD	0	0	0	0	0	0	6.2	5.0	0	0	0	0	0	0	0	0	0	6.2	6.3	0	0	0	0	0	2.7	0	0	0	0	0	0	26	37%
SCVWD	0	0	0	0	0	0	6.8	5.6	0	0	0	0	0	0	0	0	0	6.8	7.0	0	0	0	0	0	3.0	0	0	0	0	0	0	29	41%
Total From Storage	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**18**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**22**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**		**100%**
Total Desalination Used	**20**	**20**	**20**	**20**	**20**	**20**	**33**	**38**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**33**	**42**	**20**	**20**	**20**	**20**	**20**	**26**	**20**	**20**	**20**	**20**	**20**	**20**		
Additional Water Needed	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**13**	**26**	**26**	**13**	**0**	**7**	**0**	**0**	**0**	**0**	**0**	**0**		

1. Multiplied by percentage of stored water usage.

Table B-3 Projected Actual Desalination Facility Operation - Total (AFY)

Agency	Projected Annual Water Supply (AFY)																														30-Year Average	30-Year Total
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050		
CCWD																																	
Direct	0	0	0	0	0	0	0	2,729	0	0	0	0	0	0	0	0	0	0	2,729	0	2,729	2,729	0	0	0	0	0	0	0	0	0	350	
To Storage	1,523	1,523	1,523	1,523	1,523	1,523	0	0	0	0	1,523	1,523	1,523	1,523	1,523	1,523	1,523	0	0	0	0	0	0	1,523	0	1,523	1,523	1,523	1,523	1,523	1,523	980	
From Storage	0	0	0	0	0	0	0	8,125	0	0	0	0	0	0	0	0	0	0	10,135	0	0	0	0	0	0	0	0	0	0	0	0	590	
EBMUD																																	
Direct	0	0	0	0	0	0	3,182	1,889	6,718	6,718	0	0	0	0	0	0	0	3,182	1,889	3,182	1,889	1,889	3,182	0	3,182	0	0	0	0	0	0	1,200	
To Storage	2,461	2,461	2,461	2,461	2,461	2,461	0	0	0	0	2,461	2,461	2,461	2,461	2,461	2,461	2,461	0	0	0	0	0	0	2,461	0	2,461	2,461	2,461	2,461	2,461	2,461	1,600	
From Storage	0	0	0	0	0	0	6,895	5,625	0	0	0	0	0	0	0	0	0	6,895	7,017	0	0	0	0	0	3,063	0	0	0	0	0	0	950	
SCVWD																																	
Direct	0	0	0	0	0	0	3,536	2,099	0	0	0	0	0	0	0	0	0	3,536	2,099	3,536	2,099	2,099	3,536	0	3,536	0	0	0	0	0	0	800	
To Storage	2,734	2,734	2,734	2,734	2,734	2,734	0	0	0	0	2,734	2,734	2,734	2,734	2,734	2,734	2,734	0	0	0	0	0	0	2,734	0	2,734	2,734	2,734	2,734	2,734	2,734	1,800	
From Storage	0	0	0	0	0	0	7,661	6,250	0	0	0	0	0	0	0	0	0	7,661	7,796	0	0	0	0	0	3,403	0	0	0	0	0	0	1,060	
SFPUC																																	
Direct	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,100	
Zone 7																																	
Direct	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,600	
Total Desalination Facility Production (Direct + To Storage)	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,430**	**716,602**
Total Desalination Use (Direct + From Storage)	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**36,948**	**42,393**	**22,393**	**22,393**	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**36,948**	**47,341**	**22,393**	**22,393**	**22,393**	**22,393**	**15,675**	**28,859**	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**15,675**	**20,650**	

Table B-4 Desalination Supply Projections

Projected Desalination Supply

Agency	Projected Annual Water Supply (AFY)																															
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Average
CCWD	1,523	1,523	1,523	1,523	1,523	1,523	0	10,854	0	0	1,523	1,523	1,523	1,523	1,523	1,523	1,523	0	12,864	0	2,729	2,729	0	1,523	0	1,523	1,523	1,523	1,523	1,523	1,523	1,924
EBMUD	2,461	2,461	2,461	2,461	2,461	2,461	10,077	7,515	6,718	6,718	2,461	2,461	2,461	2,461	2,461	2,461	2,461	10,077	8,906	3,182	1,889	1,889	3,182	2,461	6,245	2,461	2,461	2,461	2,461	2,461	2,461	3,729
SCVWD	2,734	2,734	2,734	2,734	2,734	2,734	11,196	8,349	0	0	2,734	2,734	2,734	2,734	2,734	2,734	2,734	11,196	9,896	3,536	2,099	2,099	3,536	2,734	6,939	2,734	2,734	2,734	2,734	2,734	2,734	3,662
SFPUC	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077
Zone 7	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598
Total Desalination[1]	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**36,948**	**42,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**36,948**	**47,341**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**28,859**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**22,393**	**24,990**

Assumptions: 1. In some years, total supply exceeds annual desalination facility production limit of ~ 22,400 AFY due to storage withdrawls.

Projected Desalination Supply Energy Use

Agency	Projected Annual Energy Use (MWh/year)																																
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Average	kW
CCWD	3,778	3,778	3,778	3,778	3,778	3,778	0	7,833	0	0	3,778	4,524	3,778	3,778	3,778	4,524	3,778	0	7,833	0	7,833	7,833	0	3,778	0	3,778	3,778	3,778	3,778	3,778	3,778	3,500	400
EBMUD	6,102	6,102	6,102	6,102	6,102	6,102	11,360	6,745	20,691	20,691	6,102	7,308	6,102	6,102	6,102	7,308	6,102	11,360	6,745	11,360	6,745	6,745	11,360	6,102	11,360	6,102	6,102	6,102	6,102	6,102	6,102	8,100	920
SCVWD	6,780	6,780	6,780	6,780	6,780	6,780	14,602	8,670	0	0	6,780	8,120	6,780	6,780	6,780	8,120	6,780	14,602	8,670	14,602	8,670	8,670	14,602	6,780	14,602	6,780	6,780	6,780	6,780	6,780	6,780	7,900	900
SFPUC	30,331	30,331	30,331	30,331	30,331	30,331	35,268	35,268	30,331	30,331	30,331	35,268	30,331	30,331	30,331	35,268	30,331	35,268	35,268	35,268	35,268	35,268	35,268	30,331	35,268	30,331	30,331	30,331	30,331	30,331	30,331	32,100	3,660
Zone 7	16,738	16,738	16,738	16,738	16,738	16,738	19,482	19,482	16,738	16,738	16,738	19,482	16,738	16,738	16,738	19,482	16,738	19,482	19,482	19,482	19,482	19,482	19,482	16,738	19,482	16,738	16,738	16,738	16,738	16,738	16,738	17,700	2,020
Total Desalination	**63,729**	**63,729**	**63,729**	**63,729**	**63,729**	**63,729**	**80,712**	**77,998**	**67,760**	**67,760**	**63,729**	**74,702**	**63,729**	**63,729**	**63,729**	**74,702**	**63,729**	**80,712**	**77,998**	**80,712**	**77,998**	**77,998**	**80,712**	**63,729**	**80,712**	**63,729**	**63,729**	**63,729**	**63,729**	**63,729**	**63,729**	**69,300**	**7,910**

Projected Desalination Supply Indirect GHG Emissions

Agency	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Average
CCWD	485	485	504	491	485	485	0	1,102	0	0	491	624	485	485	485	624	485	0	1,102	0	1,102	1,102	0	491	0	485	485	485	485	485	491	465
EBMUD	784	784	814	792	784	784	1,556	924	2,615	2,685	792	1,008	784	784	784	1,008	784	1,526	924	1,526	924	924	1,556	792	1,556	784	784	784	784	784	792	1,061
SCVWD	871	871	905	880	871	871	2,054	1,220	0	0	880	1,120	871	871	871	1,120	871	2,014	1,220	2,014	1,220	1,220	2,054	880	2,054	871	871	871	871	871	880	1,066
SFPUC	3,895	3,895	4,046	3,939	3,895	3,895	4,961	4,961	3,939	4,046	3,939	4,864	3,895	3,895	3,895	4,864	3,895	4,864	4,961	4,864	4,961	4,961	4,961	3,939	4,961	3,895	3,895	3,895	3,895	3,895	3,939	4,278
Zone 7	2,150	2,150	2,233	2,174	2,150	2,150	2,740	2,740	2,174	2,233	2,174	2,687	2,150	2,150	2,150	2,687	2,150	2,687	2,740	2,687	2,740	2,740	2,740	2,174	2,740	2,150	2,150	2,150	2,150	2,150	2,174	2,362
Total Desalination	**8,184**	**8,184**	**8,502**	**8,275**	**8,184**	**8,184**	**11,311**	**10,946**	**8,727**	**8,965**	**8,275**	**10,303**	**8,184**	**8,184**	**8,184**	**10,303**	**8,184**	**11,091**	**10,946**	**11,091**	**10,946**	**10,946**	**11,311**	**8,275**	**11,311**	**8,184**	**8,184**	**8,184**	**8,184**	**8,184**	**8,275**	**9,232**

Appendix C

Partner Avoided Emissions and No Net Increase Calculations

Table C-1 CCWD No Net Increase Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology [1]	*W*	*W*	*BN*	*AN*	*W*	*W*	*C*	*C*	*AN*	*BN*	*AN*	*D*	*W*	*W*	*W*	*D*	*W*	*D*	*C*	*D*	*C*	*C*	*C*	*AN*	*C*	*W*	*W*	*W*	*W*	*W*	*AN*	
Desalination[2]																																
Direct	0	0	0	0	0	0	0	2,729	0	0	0	0	0	0	0	0	0	0	2,729	0	2,729	2,729	0	0	0	0	0	0	0	0	0	352
To Storage	1,523	1,523	1,523	1,523	1,523	1,523	0	0	0	0	1,523	1,523	1,523	1,523	1,523	1,523	1,523	0	0	0	0	0	0	1,523	0	1,523	1,523	1,523	1,523	1,523	1,523	983
From Storage	0	0	0	0	0	0	0	8,125	0	0	0	0	0	0	0	0	0	0	10,135	0	0	0	0	0	0	0	0	0	0	0	0	589
Desalination Subtotal	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**0**	**10,854**	**0**	**0**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**0**	**12,864**	**0**	**2,729**	**2,729**	**0**	**1,523**	**0**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,924**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. N = Normal, D = Drought.
2. See Tables A.1 through A.3.

Projected Water Supply Energy Use

Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[2,3]	0	0	0	0	0	0	0	7,423	0	0	0	0	0	0	0	0	0	0	7,423	0	7,423	7,423	0	0	0	0	0	0	0	0	0	958
To Storage[4,5]	3,778	3,778	3,778	3,778	3,778	3,778	0	0	0	0	3,778	4,524	3,778	3,778	3,778	4,524	3,778	0	0	0	0	0	0	3,778	0	3,778	3,778	3,778	3,778	3,778	3,778	2,486
From Storage[6]	0	0	0	0	0	0	0	409	0	0	0	0	0	0	0	0	0	0	409	0	409	409	0	0	0	0	0	0	0	0	0	53
Desalination Subtotal	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**0**	**7,833**	**0**	**0**	**3,778**	**4,524**	**3,778**	**3,778**	**3,778**	**4,524**	**3,778**	**0**	**7,833**	**0**	**7,833**	**7,833**	**0**	**3,778**	**0**	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**3,496**
Avoided Planned Purchases[7]	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**0**	**8,304**	**0**	**0**	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**0**	**9,841**	**0**	**2,088**	**2,088**	**0**	**1,165**	**0**	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**1,165**	**1,472**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + CCWD-specific additional treatment and distribution pumping energy factor.
3. 600 CCWD-specific energy to boost into multi-purpose pipeline (kWh/AF)
4. Includes Desalination process unit energy factor + storage pumping energy factor
5. 850 Storage pumping energy factor (kWh/AF)
6. 150 CCWD-specific treatment energy (kWh/AF)
7. 765 Planned Purchases (kWh/AF). Treated water with distribution. Rock Slough = 165 kwh/AF

Projected Water Supply Indirect GHG Emissions

PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286
CVP Hydropower EF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MID EF[3]	829	829	829	829	829	829	995	995	829	829	829	829	829	829	829	829	829	829	995	829	995	995	995	829	995	829	829	829	829	829	829

Water Source	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination[4]																																
Direct	0	0	0	0	0	0	0	1,044	0	0	0	0	0	0	0	0	0	0	1,044	0	1,044	1,044	0	0	0	0	0	0	0	0	0	135
To Storage	485	485	504	491	485	485	0	0	0	0	491	624	485	485	485	624	485	0	0	0	0	0	0	491	0	485	485	485	485	485	491	323
From Storage	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0	0	0	0	58	0	58	58	0	0	0	0	0	0	0	0	0	7
Desalination Subtotal	**485**	**485**	**504**	**491**	**485**	**485**	**0**	**1,102**	**0**	**0**	**491**	**624**	**485**	**485**	**485**	**624**	**485**	**0**	**1,102**	**0**	**1,102**	**1,102**	**0**	**491**	**0**	**485**	**485**	**485**	**485**	**485**	**491**	**465**
Avoided Planned Purchases[5]	**212**	**212**	**216**	**213**	**212**	**212**	**0**	**1,724**	**0**	**0**	**213**	**221**	**212**	**212**	**212**	**221**	**212**	**0**	**2,043**	**0**	**434**	**434**	**0**	**213**	**0**	**212**	**212**	**212**	**212**	**212**	**213**	**287**

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton
3. Assume 80% of 2009 MID EF, with 20% increase in planning emissions factor in drought years (due to less hydropower
1,036.2 MID 2009 Emissions Rate for Retail Power (http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/)
4. Uses PG&E electricity.
6. Uses a combination of 22% MID electricity for Rock Slough intake pumping
and 78% PG&E electricity for treatment and distribution.

No Net Increase	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Difference in GHG Emissions (Desalination minus Avoided Planned Purchases)	273	273	288	277	273	273	0	-622	0	0	277	403	273	273	273	403	273	0	-942	0	668	668	0	277	0	273	273	273	273	273	277	**178**

Table C-2 EBMUD No Net Increase Projections

Projected Water Supply																																
Water Source	**Projected Annual Water Supply (AFY)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology [1]	*N*	*N*	*N*	*N*	*N*	*N*	*D*	*D*	*D*	*D*	*N*	*D*	*N*	*N*	*N*	*D*	*N*	*D*	*D*	*D*	*D*	*D*	*D*	*N*	*D*	*N*	*N*	*N*	*N*	*N*	*N*	
Desalination[2]																																
Direct	0	0	0	0	0	0	3,182	1,889	6,718	6,718	0	0	0	0	0	0	0	3,182	1,889	3,182	1,889	1,889	3,182	0	3,182	0	0	0	0	0	0	1,190
To Storage	2,461	2,461	2,461	2,461	2,461	2,461	0	0	0	0	2,461	2,461	2,461	2,461	2,461	2,461	2,461	0	0	0	0	0	0	2,461	0	2,461	2,461	2,461	2,461	2,461	2,461	1,587
From Storage	0	0	0	0	0	0	6,895	5,625	0	0	0	0	0	0	0	0	0	6,895	7,017	0	0	0	0	0	3,063	0	0	0	0	0	0	951
Desalination Subtotal	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**10,077**	**7,515**	**6,718**	**6,718**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**10,077**	**8,906**	**3,182**	**1,889**	**1,889**	**3,182**	**2,461**	**6,245**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**3,729**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. N = Normal, D = Drought.
2. See Tables A.1 through A.3.

Projected Water Supply Energy Use																																
Desalination Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630	
Water Source	**Projected Annual Energy Use (MWh/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[2,3,4]	0	0	0	0	0	0	10,246	6,084	18,340	18,340	0	0	0	0	0	0	0	10,246	6,084	10,246	6,084	6,084	10,246	0	10,246	0	0	0	0	0	0	3,621
To Storage[5,6]	6,102	6,102	6,102	6,102	6,102	6,102	0	0	0	0	6,102	7,308	6,102	6,102	6,102	7,308	6,102	0	0	0	0	0	0	6,102	0	6,102	6,102	6,102	6,102	6,102	6,102	4,015
From Storage[4]	0	0	0	0	0	0	1,114	661	2,351	2,351	0	0	0	0	0	0	0	1,114	661	1,114	661	661	1,114	0	1,114	0	0	0	0	0	0	417
Desalination Subtotal	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**11,360**	**6,745**	**20,691**	**20,691**	**6,102**	**7,308**	**6,102**	**6,102**	**6,102**	**7,308**	**6,102**	**11,360**	**6,745**	**11,360**	**6,745**	**6,745**	**11,360**	**6,102**	**11,360**	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**8,052**
Avoided Freeport Supply[7]	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**15,780**	**11,768**	**10,520**	**10,520**	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**15,780**	**13,947**	**4,983**	**2,959**	**2,959**	**4,983**	**3,853**	**9,780**	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**3,853**	**5,840**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + EBMUD-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 350 EBMUD-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. Includes Desalination process unit energy factor + storage pumping energy factor
6. 850 Storage pumping energy factor (kWh/AF)
7. 1,566 Freeport Source surface water unit energy factor (kWh/AF)

Projected Water Supply Indirect GHG Emissions																																
PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286	
SMUD CO_2e Emissions Factor (lbs CO_2e/MWh)[3]	460	460	460	460	460	460	552	552	552	552	460	552	460	460	460	552	460	552	552	552	552	552	552	460	552	460	460	460	460	460	460	
WAPA CO_2e Emissions Factor (lbs CO_2e/MWh)[4]	0	0	0	0	0	0	100	100	100	100	0	100	0	0	0	100	0	100	100	100	100	100	100	0	100	0	0	0	0	0	0	
Water Source	**Projected Annual Indirect GHG Emissions (MT CO_2e/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[5]	0	0	0	0	0	0	1,417	841	2,343	2,406	0	0	0	0	0	0	0	1,389	841	1,389	841	841	1,417	0	1,417	0	0	0	0	0	0	489
To Storage[6]	784	784	814	792	784	784	0	0	0	0	792	1,008	784	784	784	1,008	784	0	0	0	0	0	0	792	0	784	784	784	784	784	792	522
From Storage[7]	0	0	0	0	0	0	139	82	272	279	0	0	0	0	0	0	0	136	82	136	82	82	139	0	139	0	0	0	0	0	0	51
Desalination Subtotal	**784**	**784**	**814**	**792**	**784**	**784**	**1,556**	**924**	**2,615**	**2,685**	**792**	**1,008**	**784**	**784**	**784**	**1,008**	**784**	**1,526**	**924**	**1,526**	**924**	**924**	**1,556**	**792**	**1,556**	**784**	**784**	**784**	**784**	**784**	**792**	**1,061**
Avoided Freeport Supply[8]	**609**	**609**	**619**	**612**	**609**	**609**	**2916**	**2174**	**1885**	**1904**	**612**	**706**	**609**	**609**	**609**	**706**	**609**	**2893**	**2577**	**914**	**547**	**547**	**921**	**612**	**1807**	**609**	**609**	**609**	**609**	**609**	**612**	**1,015**

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton
3. SMUD planning EF. City of Sacramento Climate Action Plan, Phase 1: Internal Operations, Community Development Department Long Range Planning, February 2010 (http://www.sacgp.org/documents/Phase-1-CAP_2-11-10.pdf)
   Assume increases 20% in drought years due to decreased hydropower availability.
4. Western Area Power Administration

	PG&E	SMUD	WAPA	Total
5. Desalination facility treatment + EBMUD treatment & distrib	97%	0%	3%	100%
6. Desalination facility treatment + pumping to LVE	100%	0%	0%	100%
7. EBMUD treatment and distribution only	83%	0%	17%	100%
8. Freeport	51%	44%	4%	100%

No Net Increase	**Projected Annual Indirect GHG Emissions (MT CO_2e/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Difference in GHG Emissions (Desalination minus Avoided Freeport Supply)	**175**	**175**	**195**	**181**	**175**	**175**	**-1,360**	**-1,251**	**730**	**781**	**181**	**301**	**175**	**175**	**175**	**301**	**175**	**-1,367**	**-1,653**	**612**	**377**	**377**	**635**	**181**	**-251**	**175**	**175**	**175**	**175**	**175**	**181**	**46**

Table C-3 SCVWD No Net Increase Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology [1]	*AN*	*BN*	*D*	*AN*	*W*	*W*	*C*	*C*	*W*	*AN*	*W*	*D*	*W*	*W*	*AN*	*D*	*W*	*C*	*C*	*C*	*C*	*C*	*C*	*W*	*C*	*W*	*W*	*W*	*W*	*AN*	*AN*	
Desalination[2]																																
Direct	0	0	0	0	0	0	3,536	2,099	0	0	0	0	0	0	0	0	0	3,536	2,099	3,536	2,099	2,099	3,536	0	3,536	0	0	0	0	0	0	841
To Storage	2,734	2,734	2,734	2,734	2,734	2,734	0	0	0	0	2,734	2,734	2,734	2,734	2,734	2,734	2,734	0	0	0	0	0	0	2,734	0	2,734	2,734	2,734	2,734	2,734	2,734	1,764
From Storage	0	0	0	0	0	0	7,661	6,250	0	0	0	0	0	0	0	0	0	7,661	7,796	0	0	0	0	0	3,403	0	0	0	0	0	0	1,057
Desalination Subtotal	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**11,196**	**8,349**	**0**	**0**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**11,196**	**9,896**	**3,536**	**2,099**	**2,099**	**3,536**	**2,734**	**6,939**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**3,662**

Assumptions:

1. Hydrology patterns are based on historical data from 1970 to 2000. Sacramento Valley Water Year Hydrologic Classification: W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.
2. See Tables A.1 through A.3.

Projected Water Supply Energy Use

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[2,3,4]	0	0	0	0	0	0	12,375	7,348	0	0	0	0	0	0	0	0	0	12,375	7,348	12,375	7,348	7,348	12,375	0	12,375	0	0	0	0	0	0	2,944
To Storage[5,6]	6,780	6,780	6,780	6,780	6,780	6,780	0	0	0	0	6,780	8,120	6,780	6,780	6,780	8,120	6,780	0	0	0	0	0	0	6,780	0	6,780	6,780	6,780	6,780	6,780	6,780	4,461
From Storage[4]	0	0	0	0	0	0	2,227	1,323	0	0	0	0	0	0	0	0	0	2,227	1,323	2,227	1,323	1,323	2,227	0	2,227	0	0	0	0	0	0	530
Desalination Subtotal	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**14,602**	**8,670**	**0**	**0**	**6,780**	**8,120**	**6,780**	**6,780**	**6,780**	**8,120**	**6,780**	**14,602**	**8,670**	**14,602**	**8,670**	**8,670**	**14,602**	**6,780**	**14,602**	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**7,935**
Avoided Imported Surface Water[7]	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**18,978**	**14,152**	**0**	**0**	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**18,978**	**16,773**	**5,993**	**3,558**	**3,558**	**5,993**	**4,634**	**11,761**	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**4,634**	**6,207**

Assumptions:

1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + SCVWD-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 630 SCVWD-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. Includes Desalination process unit energy factor + storage pumping energy factor
6. 850 Storage pumping energy factor (kWh/AF)
7. Assumes 1,695 Imported water unit energy factor (kWh/AF) from Watts to Water Report, June 2011

Projected Water Supply Indirect GHG Emissions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286

Water Source	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct	0	0	0	0	0	0	1,741	1,034	0	0	0	0	0	0	0	0	0	1,707	1,034	1,707	1,034	1,034	1,741	0	1,741	0	0	0	0	0	0	412
To Storage	871	871	905	880	871	871	0	0	0	0	880	1,120	871	871	871	1,120	871	0	0	0	0	0	0	880	0	871	871	871	871	871	880	580
From Storage	0	0	0	0	0	0	313	186	0	0	0	0	0	0	0	0	0	307	186	307	186	186	313	0	313	0	0	0	0	0	0	74
Desalination Subtotal	**871**	**871**	**905**	**880**	**871**	**871**	**2,054**	**1,220**	**0**	**0**	**880**	**1,120**	**871**	**871**	**871**	**1,120**	**871**	**2,014**	**1,220**	**2,014**	**1,220**	**1,220**	**2,054**	**880**	**2,054**	**871**	**871**	**871**	**871**	**871**	**880**	**1,066**
Avoided Imported Surface Water	**595**	**595**	**618**	**602**	**595**	**595**	**2669**	**1991**	**0**	**0**	**602**	**639**	**595**	**595**	**595**	**639**	**595**	**2617**	**2359**	**827**	**501**	**501**	**843**	**602**	**1654**	**595**	**595**	**595**	**595**	**595**	**602**	**839**

Assumptions:

1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton

No Net Increase	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Difference in GHG Emissions (Desalination minus Avoided Imported Surface Water)	**276**	**276**	**286**	**279**	**276**	**276**	**-615**	**-771**	**0**	**0**	**279**	**481**	**276**	**276**	**276**	**481**	**276**	**-603**	**-1,140**	**1,187**	**719**	**719**	**1,211**	**279**	**400**	**276**	**276**	**276**	**276**	**276**	**279**	**227**

Table C-4 SFPUC No Net Increase Projections

Projected Water Supply																																
Water Source	**Projected Annual Water Supply (AFY)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology[1]	*AN*	*BN*	*D*	*AN*	*W*	*W*	*C*	*C*	*W*	*AN*	*W*	*D*	*W*	*W*	*AN*	*D*	*W*	*C*	*C*	*C*	*C*	*C*	*C*	*W*	*C*	*W*	*W*	*W*	*W*	*AN*	*AN*	
Desalination[2]	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. Sacramento Valley Water Year Hydrologic Classification: W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.
2. See Tables A.1 through A.3.

Projected Water Supply Energy Use																																
Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630	
Water Source	**Projected Annual Energy Use (MWh/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[2,3,4]	30,331	30,331	30,331	30,331	30,331	30,331	35,268	35,268	30,331	30,331	30,331	35,268	30,331	30,331	30,331	35,268	30,331	35,268	35,268	35,268	35,268	35,268	35,268	30,331	35,268	30,331	30,331	30,331	30,331	30,331	30,331	32,083
Avoided Groundwater[5]	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126	14,126

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + SCVWD-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 630 SFPUC-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. 1,402 groundwater energy factor (kWh/AF).

Projected Water Supply Indirect GHG Emissions																																
SFPUC CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286	
Water Source	**Projected Annual Indirect GHG Emissions (MT CO_2e/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Direct	3,895	3,895	4,046	3,939	3,895	3,895	4,961	4,961	3,939	4,046	3,939	4,864	3,895	3,895	3,895	4,864	3,895	4,864	4,961	4,864	4,961	4,961	4,961	3,939	4,961	3,895	3,895	3,895	3,895	3,895	3,939	4,278
Avoided Groundwater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton

No Net Increase	**Projected Annual Indirect GHG Emissions (MT CO_2e/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Difference in GHG Emissions (Desalination minus Avoided Hetch Hetch Supply)	**3,895**	**3,895**	**4,046**	**3,939**	**3,895**	**3,895**	**4,961**	**4,961**	**3,939**	**4,046**	**3,939**	**4,864**	**3,895**	**3,895**	**3,895**	**4,864**	**3,895**	**4,864**	**4,961**	**4,864**	**4,961**	**4,961**	**4,961**	**3,939**	**4,961**	**3,895**	**3,895**	**3,895**	**3,895**	**3,895**	**3,939**	**4,278**

Table C-5 Zone 7 No Net Increase Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology [1]	*N*	*N*	*N*	*N*	*N*	*N*	*D*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*D*	*D*	*D*	*D*	*D*	*D*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	
Desalination[2]	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598

Assumptions:

1. Hydrology patterns are based on historical data from 1970 to 2000. N = Normal, D = Drought.
2. See Tables A.1 through A.3.

Projected Water Supply Energy Use

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination[2,3,4]	16,738	16,738	16,738	16,738	16,738	16,738	19,482	19,482	16,738	16,738	16,738	19,482	16,738	16,738	16,738	19,482	16,738	19,482	19,482	19,482	19,482	19,482	19,482	16,738	19,482	16,738	16,738	16,738	16,738	16,738	16,738	17,712
Avoided Imported Surface Water[5]	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235	8,235

Assumptions:

1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + Zone 7-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 610 Zone 7-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. 1,471 Imported surface water - SWP unit energy factor (kWh/AF)
Accounts for SWP operations, pumping, water treatment plants, and demineralization plant.

Projected Water Supply Indirect GHG Emissions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PG&E CO$_2$e Emissions Factor (lbs CO$_2$e/MWh)[1,2]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286
SWP CO$_2$e Emissions Factor (lbs CO$_2$e/MWh)[3]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350

Water Source	Projected Annual Indirect GHG Emissions (MT CO$_2$e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination	2,150	2,150	2,233	2,174	2,150	2,150	2,740	2,740	2,174	2,233	2,174	2,687	2,150	2,150	2,150	2,687	2,150	2,687	2,740	2,687	2,740	2,740	2,740	2,174	2,740	2,150	2,150	2,150	2,150	2,150	2,174	**2,362**
Avoided Imported Surface Water[5]	1290	1290	1292	1291	1290	1290	1295	1295	1291	1292	1291	1294	1290	1290	1290	1294	1290	1294	1295	1294	1295	1295	1295	1291	1295	1290	1290	1290	1290	1290	1291	1,292

Assumptions:

1. Conservatively using PG&E as main electricity supplier. Zone 7 is transitioning part of its power supply to PWRPA, which has a larger renewable energy portfolio.
1. PG&E AB32 planning emissions factor of 290 MT CO$_2$e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
3. Conservative (high) estimate (.158 metric tons CO2/MWh) - likely to drop as more renewables added in the future. Average value for all years; unable to get distinction between normal and dry year CO2 emissions at this time.
4. 2,204.6 lbs per metric ton
5. Different emissions factors for pumping (SWP) and for treatment (PG&E+solar). Of total energy use, 95% SWP pumping and 5% treatment and transmission during normal years; 91% SWP pumping and 9% treatment and transmission during dry years. Treatment and transmission: 9% solar and 91% PG&E.

No Net Increase	Projected Annual Indirect GHG Emissions (MT CO$_2$e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Difference in GHG Emissions (Desalination minus Avoided Imporated Surface Water)	**859**	**859**	**941**	**883**	**859**	**859**	**1,446**	**1,446**	**883**	**941**	**883**	**1,393**	**859**	**859**	**859**	**1,393**	**859**	**1,393**	**1,446**	**1,393**	**1,446**	**1,446**	**1,446**	**883**	**1,446**	**859**	**859**	**859**	**859**	**859**	**883**	**1,070**

Table C-6 BARDP No Net Increase Projections

Projected No Net Increase Emissions to Offset																																
Agency	**Projected Annual Indirect GHG Emissions (MT CO_2e/year)**																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
CCWD	273	273	288	277	273	273	0	-622	0	0	277	403	273	273	273	403	273	0	-942	0	668	668	0	277	0	273	273	273	273	273	277	178
EBMUD	175	175	195	181	175	175	-1,360	-1,251	730	781	181	301	175	175	175	301	175	-1,367	-1,653	612	377	377	635	181	-251	175	175	175	175	175	181	46
SCVWD	276	276	286	279	276	276	-615	-771	0	0	279	481	276	276	276	481	276	-603	-1,140	1,187	719	719	1,211	279	400	276	276	276	276	276	279	227
SFPUC	3,895	3,895	4,046	3,939	3,895	3,895	4,961	4,961	3,939	4,046	3,939	4,864	3,895	3,895	3,895	4,864	3,895	4,864	4,961	4,864	4,961	4,961	4,961	3,939	4,961	3,895	3,895	3,895	3,895	3,895	3,939	4,278
Zone 7	859	859	941	883	859	859	1,446	1,446	883	941	883	1,393	859	859	859	1,393	859	1,393	1,446	1,393	1,446	1,446	1,446	883	1,446	859	859	859	859	859	883	1,070
Total Desalination	**5,478**	**5,478**	**5,757**	**5,558**	**5,478**	**5,478**	**4,431**	**3,763**	**5,551**	**5,768**	**5,558**	**7,443**	**5,478**	**5,478**	**5,478**	**7,443**	**5,478**	**4,287**	**2,672**	**8,057**	**8,171**	**8,171**	**8,253**	**5,558**	**6,555**	**5,478**	**5,478**	**5,478**	**5,478**	**5,478**	**5,558**	**5,799**

Appendix D

Partner Total Water Supply Calculations

Table D-1 CCWD Total Water Supply Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																														
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Average
Hydrology[1]	*W*	*W*	*BN*	*AN*	*W*	*W*	*C*	*C*	*AN*	*BN*	*AN*	*D*	*W*	*W*	*W*	*D*	*W*	*D*	*C*	*D*	*C*	*C*	*C*	*AN*	*C*	*W*	*W*	*W*	*W*	*W*	*AN*	
Desalination[2]																																
Direct	0	0	0	0	0	0	0	2,729	0	0	0	0	0	0	0	0	0	0	2,729	0	2,729	2,729	0	0	0	0	0	0	0	0	0	352
To Storage	1,523	1,523	1,523	1,523	1,523	1,523	0	0	0	0	1,523	1,523	1,523	1,523	1,523	1,523	1,523	0	0	0	0	0	0	1,523	0	1,523	1,523	1,523	1,523	1,523	1,523	983
From Storage	0	0	0	0	0	0	0	8,125	0	0	0	0	0	0	0	0	0	0	10,135	0	0	0	0	0	0	0	0	0	0	0	0	589
Desalination Subtotal	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**0**	**10,854**	**0**	**0**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**0**	**12,864**	**0**	**2,729**	**2,729**	**0**	**1,523**	**0**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,523**	**1,924**
CVP Supply/Los Vaqueros Water Right[3]	145,200	145,200	147,600	145,200	145,200	155,500	157,900	145,863	155,500	157,900	164,600	167,000	164,600	164,600	164,600	171,900	169,500	171,900	156,250	136,750	136,750	136,750	136,750	169,500	171,900	169,500	169,500	169,500	169,500	169,500	169,500	158,110
Local Surface Water[4]	14,600	14,600	12,200	14,600	14,600	14,600	12,200	12,200	14,600	12,200	14,600	12,200	14,600	14,600	14,600	12,200	14,600	12,200	12,200	12,200	12,200	12,200	12,200	14,600	12,200	14,600	14,600	14,600	14,600	14,600	14,600	13,594
Groundwater	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Recycled Water	12,500	12,500	12,500	12,500	12,500	13,300	13,300	13,300	13,300	13,300	14,100	14,100	14,100	14,100	14,100	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,074
Planned Purchases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,271	7,200	7,200	7,200	7,200	0	0	0	0	0	0	0	0	1,002
Total Water Supply[5]	**176,823**	**176,823**	**176,823**	**176,823**	**176,823**	**187,923**	**186,400**	**185,217**	**186,400**	**186,400**	**197,823**	**197,823**	**197,823**	**197,823**	**197,823**	**203,423**	**203,423**	**201,900**	**201,385**	**173,950**	**176,679**	**176,679**	**173,950**	**203,423**	**201,900**	**203,423**	**203,423**	**203,423**	**203,423**	**203,423**	**203,423**	**191,704**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. Sacramento Valley Water Year Hydrologic Classification: W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.
2. See Tables A.1 through A.3.
3. CVP = Central Valley Project
4. ECCID and Antioch.
5. Based on 2010 UWMP. Does not include between 16,200 and 21,200 AFY of conservation savings or drought year rationing.

Projected Water Supply Energy Use

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																														
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Average
Desalination																																
Direct[2,3]	0	0	0	0	0	0	0	7,423	0	0	0	0	0	0	0	0	0	0	7,423	0	7,423	7,423	0	0	0	0	0	0	0	0	0	958
To Storage[4,5]	3,778	3,778	3,778	3,778	3,778	3,778	0	0	0	0	3,778	4,524	3,778	3,778	3,778	4,524	3,778	0	0	0	0	0	0	3,778	0	3,778	3,778	3,778	3,778	3,778	3,778	2,486
From Storage[6]	0	0	0	0	0	0	0	409	0	0	0	0	0	0	0	0	0	0	409	0	409	409	0	0	0	0	0	0	0	0	0	53
Desalination Subtotal	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**0**	**7,833**	**0**	**0**	**3,778**	**4,524**	**3,778**	**3,778**	**3,778**	**4,524**	**3,778**	**0**	**7,833**	**0**	**7,833**	**7,833**	**0**	**3,778**	**0**	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**3,778**	**3,496**
CVP Supply/Los Vaqueros Water Right[7]	145,200	145,200	147,600	145,200	145,200	155,500	157,900	145,863	155,500	157,900	164,600	167,000	164,600	164,600	164,600	171,900	169,500	171,900	156,250	136,750	136,750	136,750	136,750	169,500	171,900	169,500	169,500	169,500	169,500	169,500	169,500	158,110
Local Surface Water[8]	14,600	14,600	12,200	14,600	14,600	14,600	12,200	12,200	14,600	12,200	14,600	12,200	14,600	14,600	14,600	12,200	14,600	12,200	12,200	12,200	12,200	12,200	12,200	14,600	12,200	14,600	14,600	14,600	14,600	14,600	14,600	13,594
Groundwater[9]	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Recycled Water[10]	12,500	12,500	12,500	12,500	12,500	13,300	13,300	13,300	13,300	13,300	14,100	14,100	14,100	14,100	14,100	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,074
Planned Purchases[11]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,737	5,508	5,508	5,508	5,508	0	0	0	0	0	0	0	0	767
Total Water Supply	**177,278**	**177,278**	**177,278**	**177,278**	**177,278**	**188,378**	**184,600**	**180,395**	**184,600**	**184,600**	**198,278**	**199,024**	**198,278**	**198,278**	**198,278**	**204,624**	**203,878**	**200,100**	**194,020**	**170,458**	**178,291**	**178,291**	**170,458**	**203,878**	**200,100**	**203,878**	**203,878**	**203,878**	**203,878**	**203,878**	**203,878**	**191,241**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + CCWD-specific additional treatment and distribution pumping energy factor.
3. 600 CCWD-specific energy to boost into multi-purpose pipeline (kWh/AF)
4. Includes Desalination process unit energy factor + storage pumping energy factor
5. 850 Storage pumping energy factor (kWh/AF)
6. 150 CCWD-specific treatment energy (kWh/AF)
7. 1,000 CVP Supply unit energy factor (kWh/AF)
8. 1,000 Local surface water unit energy factor (kWh/AF). Treated water quality with distribution.
9. 400 Groundwater unit energy factor (kWh/AF). Groundwater wells are privately held and not managed by CCWD.
10. 1,000 Recycled water unit energy factor (kWh/AF)
11. 765 Planned Purchases (kWh/AF). Treated water with distribution. Rock Slough = 165 kwh/AF

Projected Water Supply Indirect GHG Emissions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286
CVP Hydropower EF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MID EF[3]	829	829	829	829	829	829	995	995	829	829	829	829	829	829	829	829	829	829	995	829	995	995	995	829	995	829	829	829	829	829	829

Water Source	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																														
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Average
Desalination4																																
Direct	0	0	0	0	0	0	0	1,044	0	0	0	0	0	0	0	0	0	0	1,044	0	1,044	1,044	0	0	0	0	0	0	0	0	0	135
To Storage	485	485	504	491	485	485	0	0	0	0	491	624	485	485	485	624	485	0	0	0	0	0	0	491	0	485	485	485	485	485	491	323
From Storage	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0	0	0	0	58	0	58	58	0	0	0	0	0	0	0	0	0	7
Desalination Subtotal	**485**	**485**	**504**	**491**	**485**	**485**	**0**	**1,102**	**0**	**0**	**491**	**624**	**485**	**485**	**485**	**624**	**485**	**0**	**1,102**	**0**	**1,102**	**1,102**	**0**	**491**	**0**	**485**	**485**	**485**	**485**	**485**	**491**	**465**
CVP Supply/Los Vaqueros Water Right[5]	21,480	21,480	22,145	21,568	21,480	23,004	27,140	25,071	23,098	23,690	24,450	25,372	24,350	24,350	24,350	26,117	25,075	26,117	26,856	20,776	23,505	23,505	23,505	25,177	29,546	25,075	25,075	25,075	25,075	25,075	25,177	24,315
Local Surface Water[6]	5,490	5,490	4,587	5,490	5,490	5,490	5,505	5,505	5,490	4,587	5,490	4,587	5,490	5,490	5,490	4,587	5,490	4,587	5,505	4,587	5,505	5,505	5,505	5,490	5,505	5,490	5,490	5,490	5,490	5,490	5,490	5,318
Groundwater[4]	154	154	160	156	154	154	169	169	156	160	156	166	154	154	154	166	154	166	169	166	169	169	169	156	169	154	154	154	154	154	156	160
Recycled Water[4]	1,605	1,605	1,668	1,623	1,605	1,708	1,871	1,871	1,727	1,774	1,831	1,945	1,811	1,811	1,811	2,041	1,901	2,041	2,082	2,041	2,082	2,082	2,082	1,922	2,082	1,901	1,901	1,901	1,901	1,901	1,922	1,872
Planned Purchases[6]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	361	1,043	1,144	1,144	1,144	0	0	0	0	0	0	0	0	156
Total Water Supply	**29,215**	**29,215**	**29,064**	**29,327**	**29,215**	**30,841**	**34,684**	**33,717**	**30,470**	**30,212**	**32,417**	**32,694**	**32,290**	**32,290**	**32,290**	**33,535**	**33,105**	**32,911**	**36,074**	**28,613**	**33,505**	**33,505**	**32,404**	**33,235**	**37,301**	**33,105**	**33,105**	**33,105**	**33,105**	**33,105**	**33,235**	**32,287**

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton
3. Assume 80% of 2009 MID EF, with 20% increase in planning emissions factor in drought years (due to less hydropower
1,036.2 MID 2009 Emissions Rate for Retail Power (http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/)
4. Uses PG&E electricity.
5. Uses a blend of PG&E, CVP, and MID electricity:

Power Source	Raw Water	Water Treatment	TW Conveyance	Total	Water Treatment and Conveyance
PG&E	26%	100%	45%	42%	70%
CVP	52%	0%	0%	33%	0
MID	22%	0%	55%	25%	30%

6. Uses a combination of 22% MID electricity for Rock Slough intake pumping

Table D-2 EBMUD Water Supply Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																														
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology[1]	*N*	*N*	*N*	*N*	*N*	*N*	*D*	*D*	*D*	*D*	*N*	*D*	*N*	*N*	*N*	*D*	*N*	*D*	*D*	*D*	*D*	*D*	*D*	*N*	*D*	*N*	*N*	*N*	*N*	*N*	*N*	
Desalination[2]																																
Direct	0	0	0	0	0	0	3,182	1,889	6,718	6,718	0	0	0	0	0	0	0	3,182	1,889	3,182	1,889	1,889	3,182	0	3,182	0	0	0	0	0	0	1,190
To Storage	2,461	2,461	2,461	2,461	2,461	2,461	0	0	0	0	2,461	2,461	2,461	2,461	2,461	2,461	2,461	0	0	0	0	0	0	2,461	0	2,461	2,461	2,461	2,461	2,461	2,461	1,587
From Storage	0	0	0	0	0	0	6,895	5,625	0	0	0	0	0	0	0	0	0	6,895	7,017	0	0	0	0	0	3,063	0	0	0	0	0	0	951
Desalination Subtotal	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**10,077**	**7,515**	**6,718**	**6,718**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**10,077**	**8,906**	**3,182**	**1,889**	**1,889**	**3,182**	**2,461**	**6,245**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**2,461**	**3,729**
Imported Surface Water[3]	257,700	257,700	258,200	257,700	257,700	257,700	184,000	147,100	116,800	139,900	235,600	190,900	241,100	257,700	258,200	190,900	229,200	186,000	134,500	221,400	161,400	153,200	185,600	250,700	187,000	218,800	258,200	257,700	257,700	257,700	257,700	216,958
Freeport Supply	0	0	0	0	0	0	65,800	76,000	23,200	65,800	16,600	65,800	16,400	0	0	65,800	28,300	65,800	93,400	6,100	65,800	66,600	32,900	0	65,800	37,800	0	0	0	0	0	27,674
Groundwater	0	0	0	0	0	0	900	1,100	1,100	1,100	200	900	200	0	0	900	200	900	1,100	1,100	1,100	1,100	1,100	200	900	200	0	0	0	0	0	461
Recycled Water	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,326
Total Water Supply[4]	**272,461**	**272,461**	**273,061**	**272,461**	**272,461**	**272,461**	**273,177**	**244,015**	**160,118**	**225,818**	**267,261**	**272,361**	**272,461**	**272,461**	**273,061**	**272,361**	**272,461**	**275,077**	**250,306**	**244,082**	**242,489**	**235,089**	**235,182**	**265,661**	**272,245**	**271,561**	**273,061**	**272,461**	**272,461**	**272,461**	**272,561**	**261,149**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. N = Normal, D = Drought.
2. See Tables A.1 through A.3.
3. Mokelumne supply, with a small portion of local supplies.
4. Water supply projections based on Ben Bray's EBMUD SIM analysis.
   2040 Demand Scenario, 230 MGD demand including Conservation and Recycling, 15% rationing (EOS TSS 500-400-300), FRWP/Bayside, DPS = 1976-1977-185TAF
   Conservation = 43,700 to 43,800 AFY
   Supplemental Supply need based on Bluestein projections:
      2040 supplemental supply need is 113 TAF over three years, 20% is taken in the first year of any drought, 40% is taken in the next two consecutive dry years. If the drought continues, the three-year cycle restarts.

Projected Water Supply Energy Use

Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																														
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[2,3,4]	0	0	0	0	0	0	10,246	6,084	18,340	18,340	0	0	0	0	0	0	0	10,246	6,084	10,246	6,084	6,084	10,246	0	10,246	0	0	0	0	0	0	3,621
To Storage[5,6]	6,102	6,102	6,102	6,102	6,102	6,102	0	0	0	0	6,102	7,308	6,102	6,102	6,102	7,308	6,102	0	0	0	0	0	0	6,102	0	6,102	6,102	6,102	6,102	6,102	6,102	4,015
From Storage[4]	0	0	0	0	0	0	1,114	661	2,351	2,351	0	0	0	0	0	0	0	1,114	661	1,114	661	661	1,114	0	1,114	0	0	0	0	0	0	417
Desalination Subtotal	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**11,360**	**6,745**	**20,691**	**20,691**	**6,102**	**7,308**	**6,102**	**6,102**	**6,102**	**7,308**	**6,102**	**11,360**	**6,745**	**11,360**	**6,745**	**6,745**	**11,360**	**6,102**	**11,360**	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**6,102**	**8,052**
Imported Surface Water[6]	84,232	84,232	84,396	84,232	84,232	84,232	60,143	48,081	38,178	45,728	77,009	62,398	78,807	84,232	84,396	62,398	74,917	60,796	43,963	72,367	52,756	50,075	60,666	81,944	61,123	71,518	84,396	84,232	84,232	84,232	84,232	70,915
Freeport Supply[7]	0	0	0	0	0	0	103,043	119,016	36,331	103,043	25,996	103,043	25,682	0	0	103,043	44,318	103,043	146,265	9,553	103,043	104,296	51,522	0	103,043	59,195	0	0	0	0	0	43,338
Groundwater[8]	0	0	0	0	0	0	360	440	440	440	80	360	80	0	0	360	80	360	440	440	440	440	440	80	360	80	0	0	0	0	0	184
Recycled Water[9]	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,300	12,300	12,300	12,400	12,326
Total Water Supply	**102,635**	**102,635**	**102,898**	**102,635**	**102,635**	**102,635**	**187,306**	**186,583**	**107,939**	**182,202**	**121,587**	**185,409**	**122,971**	**102,635**	**102,898**	**185,409**	**137,717**	**187,859**	**209,813**	**106,020**	**175,284**	**173,856**	**136,387**	**100,426**	**188,186**	**149,194**	**102,898**	**102,635**	**102,635**	**102,635**	**102,735**	**134,816**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + EBMUD-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 350 EBMUD-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. Includes Desalination process unit energy factor + storage pumping energy factor
6. 850 Storage pumping energy factor (kWh/AF)
7. 327 Mokelumne Source surface water (Normal years) unit energy factor (kWh/AF)
8. 1,566 Freeport Source surface water unit energy factor (kWh/AF)
9. 400 Groundwater unit energy factor (kWh/AF)
10. 1,000 Recycled water unit energy factor (kWh/AF)

Projected Water Supply Indirect GHG Emissions

PG&E CO$_2$e Emissions Factor (lbs CO$_2$e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286
SMUD CO$_2$e Emissions Factor (lbs CO$_2$e/MWh)[3]	460	460	460	460	460	460	552	552	552	552	460	552	460	460	460	552	460	552	552	552	552	552	552	460	552	460	460	460	460	460	460
WAPA CO$_2$e Emissions Factor (lbs CO$_2$e/MWh)[4]	0	0	0	0	0	0	100	100	100	100	0	100	0	0	0	100	0	100	100	100	100	100	100	0	100	0	0	0	0	0	0

Water Source	Projected Annual Indirect GHG Emissions (MT CO$_2$e/year)																														
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[5]	0	0	0	0	0	0	1,417	841	2,343	2,406	0	0	0	0	0	0	0	1,389	841	1,389	841	841	1,417	0	1,417	0	0	0	0	0	0	489
To Storage[6]	784	784	814	792	784	784	0	0	0	0	792	1,008	784	784	784	1,008	784	0	0	0	0	0	0	792	0	784	784	784	784	784	792	522
From Storage[7]	0	0	0	0	0	0	139	82	272	279	0	0	0	0	0	0	0	136	82	136	82	82	139	0	139	0	0	0	0	0	0	51
Desalination Subtotal	**784**	**784**	**814**	**792**	**784**	**784**	**1,556**	**924**	**2,615**	**2,685**	**792**	**1,008**	**784**	**784**	**784**	**1,008**	**784**	**1,526**	**924**	**1,526**	**924**	**924**	**1,556**	**792**	**1,556**	**784**	**784**	**784**	**784**	**784**	**792**	**1,061**
Imported Surface Water[8]	8,998	8,998	9,355	9,095	8,998	8,998	7,542	6,029	4,454	5,466	8,315	7,686	8,418	8,998	9,015	7,686	8,003	7,489	5,513	8,914	6,615	6,279	7,607	8,848	7,665	7,639	9,015	8,998	8,998	8,998	9,095	7,991
Freeport Supply[9]	0	0	0	0	0	0	19,038	21,989	6,510	18,653	4,128	18,893	4,059	0	0	18,893	7,004	18,893	27,024	1,751	19,038	19,270	9,519	0	19,038	9,356	0	0	0	0	0	7,841
Groundwater[10]	0	0	0	0	0	0	51	62	57	59	10	50	10	0	0	50	10	50	62	61	62	62	62	10	51	10	0	0	0	0	0	25
Recycled Water[7]	1,315	1,315	1,377	1,329	1,315	1,315	1,546	1,533	1,423	1,459	1,340	1,505	1,315	1,315	1,325	1,505	1,315	1,505	1,546	1,505	1,533	1,533	1,546	1,329	1,533	1,315	1,325	1,315	1,315	1,315	1,340	1,403
Total Water Supply	**11,096**	**11,096**	**11,546**	**11,217**	**11,096**	**11,096**	**29,732**	**30,538**	**15,059**	**28,323**	**14,586**	**29,142**	**14,586**	**11,096**	**11,124**	**29,142**	**17,115**	**29,463**	**35,068**	**13,758**	**28,173**	**28,068**	**20,290**	**10,980**	**29,843**	**19,104**	**11,124**	**11,096**	**11,096**	**11,096**	**11,227**	**18,322**

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO$_2$e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton
3. SMUD planning EF. City of Sacramento Climate Action Plan, Phase 1: Internal Operations, Community Development Department Long Range Planning, February 2010 (http://www.sacgp.org/documents/Phase-1-CAP_2-11-10.pdf)
   Assume increases 20% in drought years due to decreased hydropower availability.
4. Western Area Power Administration

	PG&E	SMUD	WAPA	Total
5. Desalination facility treatment + EBMUD treatment & distrib	97%	0%	3%	100%
6. Desalination facility treatment + pumping to LVE	100%	0%	0%	100%
7. EBMUD treatment and distribution only	83%	0%	17%	100%
8. Mokelumne	81%	2%	18%	100%
9. Freeport	51%	44%	4%	100%
10. Groundwater	100%	0%	0%	100%

Table D-3 SCVWD Water Supply Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology[1]	*AN*	*BN*	*D*	*AN*	*W*	*W*	*C*	*C*	*W*	*AN*	*W*	*D*	*W*	*W*	*AN*	*D*	*W*	*C*	*C*	*C*	*C*	*C*	*C*	*W*	*C*	*W*	*W*	*W*	*W*	*AN*	*AN*	
Desalination[2]																																
Direct	0	0	0	0	0	0	3,536	2,099	0	0	0	0	0	0	0	0	0	3,536	2,099	3,536	2,099	2,099	3,536	0	3,536	0	0	0	0	0	0	841
To Storage	2,734	2,734	2,734	2,734	2,734	2,734	0	0	0	0	2,734	2,734	2,734	2,734	2,734	2,734	2,734	0	0	0	0	0	0	2,734	0	2,734	2,734	2,734	2,734	2,734	2,734	1,764
From Storage	0	0	0	0	0	0	7,661	6,250	0	0	0	0	0	0	0	0	0	7,661	7,796	0	0	0	0	0	3,403	0	0	0	0	0	0	1,057
Desalination Subtotal	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**11,196**	**8,349**	**0**	**0**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**11,196**	**9,896**	**3,536**	**2,099**	**2,099**	**3,536**	**2,734**	**6,939**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**2,734**	**3,662**
Imported Surface Water[3]	172,100	172,100	172,100	172,100	172,100	172,100	111,700	111,700	172,100	172,100	172,100	172,100	172,100	172,100	172,100	172,100	172,100	140,770	140,770	140,770	140,770	140,770	140,770	172,100	111,700	172,100	172,100	172,100	172,100	172,100	172,100	160,191
Local Surface Water	145,020	145,020	145,020	145,020	145,020	145,020	63,600	63,600	145,020	145,020	145,020	145,020	145,020	145,020	145,020	145,020	145,020	102,300	102,300	102,300	102,300	102,300	102,300	145,020	63,600	145,020	145,020	145,020	145,020	145,020	145,020	128,872
Groundwater[4]	0	0	0	0	0	0	153,940	153,940	0	0	0	0	0	0	0	0	0	51,750	51,750	51,750	51,750	51,750	51,750	0	167,290	0	0	0	0	0	0	25,344
Recycled Water	25,780	25,780	25,780	25,780	25,780	25,780	29,180	29,180	25,780	25,780	25,780	25,780	25,780	25,780	25,780	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	29,380	27,857
Hetch Hetchy Water	63,850	63,850	63,850	63,850	63,850	63,850	50,950	50,950	63,850	63,850	63,850	63,850	63,850	63,850	63,850	63,700	63,700	66,750	66,750	66,750	66,750	66,750	66,750	63,700	50,950	63,700	63,700	63,700	63,700	63,700	63,700	63,119
Total Water Supply[5]	**409,484**	**409,484**	**409,484**	**409,484**	**409,484**	**409,484**	**420,566**	**417,719**	**406,750**	**406,750**	**409,484**	**409,484**	**409,484**	**409,484**	**409,484**	**412,934**	**412,934**	**402,146**	**400,846**	**394,486**	**393,049**	**393,049**	**394,486**	**412,934**	**429,859**	**412,934**	**412,934**	**412,934**	**412,934**	**412,934**	**412,934**	**409,046**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. Sacramento Valley Water Year Hydrologic Classification: W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.
2. See Tables A.1 through A.3.
3. Includes State Water Project (SWP), CVP and Semitropic.
4. Refers to the net change in capacity at the basins.
5. Projections from 2020 to 2035 are from the 2010 UWMP; 2036 through 2050 are same as 2035. Includes conservation, rationing, and projected demand increases.

Projected Water Supply Energy Use

Desalination Process Unit Energy Factor (kWh/AF)[1]	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct[2,3,4]	0	0	0	0	0	0	12,375	7,348	0	0	0	0	0	0	0	0	0	12,375	7,348	12,375	7,348	7,348	12,375	0	12,375	0	0	0	0	0	0	2,944
To Storage[5,6]	6,780	6,780	6,780	6,780	6,780	6,780	0	0	0	0	6,780	8,120	6,780	6,780	6,780	8,120	6,780	0	0	0	0	0	0	6,780	0	6,780	6,780	6,780	6,780	6,780	6,780	4,461
From Storage[4]	0	0	0	0	0	0	2,227	1,323	0	0	0	0	0	0	0	0	0	2,227	1,323	2,227	1,323	1,323	2,227	0	2,227	0	0	0	0	0	0	530
Desalination Subtotal	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**14,602**	**8,670**	**0**	**0**	**6,780**	**8,120**	**6,780**	**6,780**	**6,780**	**8,120**	**6,780**	**14,602**	**8,670**	**14,602**	**8,670**	**8,670**	**14,602**	**6,780**	**14,602**	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**6,780**	**7,935**
Imported Surface Water[7]	291,710	291,710	291,710	291,710	291,710	291,710	189,332	189,332	291,710	291,710	291,710	291,710	291,710	291,710	291,710	291,710	291,710	238,605	238,605	238,605	238,605	238,605	238,605	291,710	189,332	291,710	291,710	291,710	291,710	291,710	291,710	271,524
Local Surface Water[8]	121,962	121,962	121,962	121,962	121,962	121,962	53,488	53,488	121,962	121,962	121,962	121,962	121,962	121,962	121,962	121,962	121,962	86,034	86,034	86,034	86,034	86,034	86,034	121,962	53,488	121,962	121,962	121,962	121,962	121,962	121,962	108,382
Groundwater[9]	0	0	0	0	0	0	214,438	214,438	0	0	0	0	0	0	0	0	0	72,088	72,088	72,088	72,088	72,088	72,088	0	233,035	0	0	0	0	0	0	35,304
Recycled Water[10]	17,891	17,891	17,891	17,891	17,891	17,891	20,251	20,251	17,891	17,891	17,891	17,891	17,891	17,891	17,891	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	20,390	19,333
Hetch Hetchy Water[11]	10,408	10,408	10,408	10,408	10,408	10,408	8,305	8,305	10,408	10,408	10,408	10,408	10,408	10,408	10,408	10,383	10,383	10,880	10,880	10,880	10,880	10,880	10,880	10,383	8,305	10,383	10,383	10,383	10,383	10,383	10,383	10,288
Total Water Supply	**448,750**	**448,750**	**448,750**	**448,750**	**448,750**	**448,750**	**500,416**	**494,483**	**441,970**	**441,970**	**448,750**	**450,090**	**448,750**	**448,750**	**448,750**	**452,564**	**451,224**	**442,600**	**436,667**	**442,600**	**436,667**	**436,667**	**442,600**	**451,224**	**519,151**	**451,224**	**451,224**	**451,224**	**451,224**	**451,224**	**451,224**	**452,766**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + SCVWD-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 630 SCVWD-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. Includes Desalination process unit energy factor + storage pumping energy factor
6. 850 Storage pumping energy factor (kWh/AF)
7. 1,695 Imported water unit energy factor (kWh/AF) from Watts to Water Report, June 2011
8. 841 Local surface water unit energy factor (kWh/AF) from Watts to Water Report, June 2011
9. 1,393 Groundwater unit energy factor (kWh/AF) from Watts to Water Report, June 2011
10. 694 Recycled water unit energy factor (kWh/AF) from Watts to Water Report, June 2011
11. 163 Hetch Hetchy unit energy factor (kWh/AF)

Projected Water Supply Indirect GHG Emissions

PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286

Water Source	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination																																
Direct	0	0	0	0	0	0	1,741	1,034	0	0	0	0	0	0	0	0	0	1,707	1,034	1,707	1,034	1,034	1,741	0	1,741	0	0	0	0	0	0	412
To Storage	871	871	905	880	871	871	0	0	0	0	880	1,120	871	871	871	1,120	871	0	0	0	0	0	0	880	0	871	871	871	871	871	880	580
From Storage	0	0	0	0	0	0	313	186	0	0	0	0	0	0	0	0	0	307	186	307	186	186	313	0	313	0	0	0	0	0	0	74
Desalination Subtotal	**871**	**871**	**905**	**880**	**871**	**871**	**2,054**	**1,220**	**0**	**0**	**880**	**1,120**	**871**	**871**	**871**	**1,120**	**871**	**2,014**	**1,220**	**2,014**	**1,220**	**1,220**	**2,054**	**880**	**2,054**	**871**	**871**	**871**	**871**	**871**	**880**	**1,066**
Imported Surface Water	37,461	37,461	38,917	37,879	37,461	37,461	26,632	26,632	37,879	38,917	37,879	40,234	37,461	37,461	37,461	40,234	37,461	32,909	33,563	32,909	33,563	33,563	33,563	37,879	26,632	37,461	37,461	37,461	37,461	37,461	37,879	35,957
Local Surface Water	15,662	15,662	16,271	15,837	15,662	15,662	7,524	7,524	15,837	16,271	15,837	16,821	15,662	15,662	15,662	16,821	15,662	11,866	12,102	11,866	12,102	12,102	12,102	15,837	7,524	15,662	15,662	15,662	15,662	15,662	15,837	14,313
Groundwater	0	0	0	0	0	0	30,164	30,164	0	0	0	0	0	0	0	0	0	9,943	10,140	9,943	10,140	10,140	10,140	0	32,780	0	0	0	0	0	0	4,953
Recycled Water	2,298	2,298	2,387	2,323	2,298	2,298	2,849	2,849	2,323	2,387	2,323	2,468	2,298	2,298	2,298	2,812	2,618	2,812	2,868	2,812	2,868	2,868	2,868	2,648	2,868	2,618	2,618	2,618	2,618	2,618	2,648	2,573
Hetch Hetchy Water	1,337	1,337	1,388	1,351	1,337	1,337	1,168	1,168	1,351	1,388	1,351	1,435	1,337	1,337	1,337	1,432	1,333	1,501	1,530	1,501	1,530	1,530	1,530	1,348	1,168	1,333	1,333	1,333	1,333	1,333	1,348	1,367
Total Water Supply	**57,629**	**57,629**	**59,867**	**58,272**	**57,629**	**57,629**	**70,390**	**69,556**	**57,391**	**58,963**	**58,272**	**62,078**	**57,629**	**57,629**	**57,629**	**62,419**	**57,946**	**61,045**	**61,423**	**61,045**	**61,423**	**61,423**	**62,258**	**58,593**	**73,026**	**57,946**	**57,946**	**57,946**	**57,946**	**57,946**	**58,593**	**60,230**

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton

Table D-4 SFPUC Water Supply Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology [1]	*AN*	*BN*	*D*	*AN*	*W*	*W*	*C*	*C*	*W*	*AN*	*W*	*D*	*W*	*W*	*AN*	*D*	*W*	*C*	*C*	*C*	*C*	*C*	*C*	*W*	*C*	*W*	*W*	*W*	*W*	*AN*	*AN*	
Desalination[2]	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077	10,077
Hetch Hetchy and Local Water	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Total Water Supply	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**	**310,077**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. Sacramento Valley Water Year Hydrologic Classification: W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.
2. See Tables A.1 through A.3.

Projected Water Supply Energy Use

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination[2,3,4]	30,331	30,331	30,331	30,331	30,331	30,331	35,268	35,268	30,331	30,331	30,331	35,268	30,331	30,331	30,331	35,268	30,331	35,268	35,268	35,268	35,268	35,268	35,268	30,331	35,268	30,331	30,331	30,331	30,331	30,331	30,331	32,083
Hetch Hetchy Water[5]	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133	194,133
Total Water Supply	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**	**194,133**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + SCVWD-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 630 SFPUC-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. 647 Unit energy factor (kWh/AF). Assumes 75% Hetch Hetchy at 163 kWh/AF
10% groundwater at 1,402 kWh/AF
5% recycled water at 1,174 kWh/AF
plus 326 kWh/AF for in-city retail.

Projected Water Supply Indirect GHG Emissions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
SFPUC CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286

Water Source	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination	3,895	3,895	4,046	3,939	3,895	3,895	4,961	4,961	3,939	4,046	3,939	4,864	3,895	3,895	3,895	4,864	3,895	4,864	4,961	4,864	4,961	4,961	4,961	3,939	4,961	3,895	3,895	3,895	3,895	3,895	3,939	4,278
Hetch Hetchy Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Water Supply	**3,895**	**3,895**	**4,046**	**3,939**	**3,895**	**3,895**	**4,961**	**4,961**	**3,939**	**4,046**	**3,939**	**4,864**	**3,895**	**3,895**	**3,895**	**4,864**	**3,895**	**4,864**	**4,961**	**4,864**	**4,961**	**4,961**	**4,961**	**3,939**	**4,961**	**3,895**	**3,895**	**3,895**	**3,895**	**3,895**	**3,939**	**4,278**

Assumptions:
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
2. 2,204.6 lbs per metric ton

Table D-5 Zone 7 Total Water Supply Projections

Projected Water Supply

Water Source	Projected Annual Water Supply (AFY)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Hydrology [1]	*N*	*N*	*N*	*N*	*N*	*N*	*D*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*D*	*D*	*D*	*D*	*D*	*D*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	
Desalination[2]	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598	5,598
Imported Surface Water (SWP)	41,600	41,600	41,600	41,600	41,600	41,600	8,000	41,400	41,400	41,400	37,700	37,700	37,700	37,700	37,700	37,700	21,100	23,900	47,800	15,700	22,700	19,500	37,700	37,700	37,700	37,700	37,700	37,700	37,700	37,700	37,700	35,419
Imported Surface Water (Byron Bethany ID)	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Local Surface Water	7,300	7,300	7,300	7,300	7,300	8,900	0	8,900	8,900	8,900	12,700	12,700	12,700	12,700	12,700	12,700	930	350	520	150	4,400	5,300	12,700	12,700	12,700	12,700	12,700	12,700	12,700	12,700	12,700	8,847
Groundwater	7,000	7,000	7,000	7,000	7,000	7,000	26,200	7,000	7,000	7,000	10,700	10,700	10,700	10,700	10,700	10,700	14,000	14,000	14,000	14,000	14,000	14,000	10,700	10,700	10,700	10,700	10,700	10,700	10,700	10,700	10,700	10,765
Non-Local Storage	0	0	0	0	0	0	19,100	0	0	0	0	0	0	0	0	0	20,300	20,700	23,600	19,600	20,500	20,100	0	0	0	0	0	0	0	0	0	4,642
Total Water Supply[3]	**66,498**	**66,498**	**66,498**	**66,498**	**66,498**	**68,098**	**63,898**	**67,898**	**67,898**	**67,898**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**66,928**	**69,548**	**96,518**	**60,048**	**72,198**	**69,498**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**71,698**	**70,271**

Assumptions:
1. Hydrology patterns are based on historical data from 1970 to 2000. N = Normal, D = Drought.
2. See Tables A.1 through A.3.
3. Based on intertie portfolio analysis completed as part of the 2011 Water Supply Evaluation. Supply needs assume 10% water conservation savings.

Projected Water Supply Energy Use

Desalination Process Unit Energy Factor (kWh/AF)[1]	1,630	1,630	1,630	1,630	1,630	1,630	2,120	2,120	1,630	1,630	1,630	2,120	1,630	1,630	1,630	2,120	1,630	2,120	2,120	2,120	2,120	2,120	2,120	1,630	2,120	1,630	1,630	1,630	1,630	1,630	1,630

Water Source	Projected Annual Energy Use (MWh/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination[2,3,4]	16,738	16,738	16,738	16,738	16,738	16,738	19,482	19,482	16,738	16,738	16,738	19,482	16,738	16,738	16,738	19,482	16,738	19,482	19,482	19,482	19,482	19,482	19,482	16,738	19,482	16,738	16,738	16,738	16,738	16,738	16,738	17,712
Imported Surface Water (SWP)	61,194	61,194	61,194	61,194	61,194	61,194	11,768	60,899	60,899	60,899	55,457	55,457	55,457	55,457	55,457	55,457	31,038	35,157	70,314	23,095	33,392	28,685	55,457	55,457	55,457	55,457	55,457	55,457	55,457	55,457	55,457	52,102
Imported Surface Water (BBID)	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355	7,355
Local Surface Water	752	752	752	752	752	917	0	917	917	917	1,308	1,308	1,308	1,308	1,308	1,308	96	36	54	15	453	546	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	911
Groundwater	4,613	4,613	4,613	4,613	4,613	4,613	17,999	4,613	4,613	4,613	7,051	7,051	7,051	7,051	7,051	7,051	9,618	9,618	9,618	9,618	9,618	9,618	7,051	7,051	7,051	7,051	7,051	7,051	7,051	7,051	7,051	7,193
Non-Local Storage	0	0	0	0	0	0	42,880	0	0	0	0	0	0	0	0	0	45,574	46,472	52,982	44,002	46,023	45,125	0	0	0	0	0	0	0	0	0	10,421
Total Water Supply[5]	**73,914**	**73,914**	**73,914**	**73,914**	**73,914**	**74,078**	**80,002**	**73,784**	**73,784**	**73,784**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**93,680**	**98,637**	**140,322**	**84,085**	**96,840**	**91,328**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**71,171**	**77,983**

Assumptions:
1. Desalination process unit energy factor is the same for all partners. Varies based on salinity/drought conditions of source water.
2. Includes Desalination process unit energy factor + Zone 7-specific additional treatment and distribution pumping energy factor.
3. 750 Energy to Pump to Mokelumne Aqueducts at Clyde Wasteway (kWh/AF)
4. 610 Zone 7-specific additional treatment and distribution pumping energy factor (kWh/AF)
5. Energy use factors account for SWP operations, pumping, water treatment plants, and demineralization plant.

Normal Years

1,471 Imported surface water - SWP unit energy factor (kWh/AF)

0 Non-Local Storage unit energy factor (kWh/AF)
103 Local surface water unit energy factor (kWh/AF)

659 Groundwater unit energy factor (kWh/AF)

1,471 Imported surface water - BBID unit energy factor (kWh/AF)

Dry Years
1,471 Imported surface water - SWP unit energy factor (kWh/AF)
2,245 Non-Local Storage unit energy factor (kWh/AF)
103 Local surface water unit energy factor (kWh/AF)

687 Groundwater unit energy factor (kWh/AF)

1,471 Imported surface water - BBID unit energy factor (kWh/AF)

Projected Water Supply Indirect GHG Emissions

PG&E CO_2e Emissions Factor (lbs CO_2e/MWh)[1,2]	283	283	294	286	283	283	310	310	286	294	286	304	283	283	283	304	283	304	310	304	310	310	310	286	310	283	283	283	283	283	286
SWP CO_2e Emissions Factor (lbs CO_2e/MWh)[3]	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350

Water Source	Projected Annual Indirect GHG Emissions (MT CO_2e/year)																															
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Average**
Desalination	2,150	2,150	2,233	2,174	2,150	2,150	2,740	2,740	2,174	2,233	2,174	2,687	2,150	2,150	2,150	2,687	2,150	2,687	2,740	2,687	2,740	2,740	2,740	2,174	2,740	2,150	2,150	2,150	2,150	2,150	2,174	**2,362**
Imported Surface Water (SWP)[5]	9,587	9,587	9,601	9,591	9,587	9,587	1,850	9,575	9,545	9,555	8,692	8,712	8,688	8,688	8,688	8,712	4,863	5,523	11,055	3,628	5,250	4,510	8,719	8,692	8,719	8,688	8,688	8,688	8,688	8,688	8,692	8,172
Imported Surface Water (BBID)[8]	1,140	1,140	1,143	1,141	1,140	1,140	1,147	1,147	1,141	1,143	1,141	1,146	1,140	1,140	1,140	1,146	1,140	1,146	1,147	1,146	1,147	1,147	1,147	1,141	1,147	1,140	1,140	1,140	1,140	1,140	1,141	1,143
Local Surface Water[7]	81	81	84	82	81	99	0	108	100	103	143	152	141	141	141	152	10	4	6	2	54	65	155	143	155	141	141	141	141	141	143	101
Groundwater[1]	592	592	615	599	592	592	2,532	649	599	615	916	973	906	906	906	973	1,235	1,327	1,353	1,327	1,353	1,353	992	916	992	906	906	906	906	906	916	963
Non-Local Storage[6]	0	0	0	0	0	0	6,742	0	0	0	0	0	0	0	0	0	7,140	7,301	8,330	6,913	7,236	7,095	0	0	0	0	0	0	0	0	0	1,637
Total Water Supply	**11,400**	**11,400**	**11,443**	**11,413**	**11,400**	**11,418**	**12,271**	**11,479**	**11,385**	**11,416**	**10,891**	**10,982**	**10,875**	**10,875**	**10,875**	**10,982**	**14,388**	**15,300**	**21,891**	**13,015**	**15,039**	**14,169**	**11,013**	**10,891**	**11,013**	**10,875**	**10,875**	**10,875**	**10,875**	**10,875**	**10,891**	**12,016**

Assumptions:
1. Conservatively using PG&E as main electricity supplier. Zone 7 is transitioning part of its power supply to PWRPA, which has a larger renewable energy portfolio.
1. PG&E AB32 planning emissions factor of 290 MT CO_2e is used but modified based on Sacramento Valley Water Year Hydrologic Classification for historical equivalent water years. PG&E AB32 planning factor is based on E3 GHG Calculator for California Electricity Sector, Version 3c, October 2010 (http://www.ethree.com).
3. Conservative (high) estimate (.158 metric tons CO2/MWh) - likely to drop as more renewables added in the future. Average value for all years; unable to get distinction between normal and dry year CO2 emissions at this time.
4. 2,204.6 lbs per metric ton
5. Different emissions factors for pumping (SWP) and for treatment (PG&E+solar). Of total energy use, 95% SWP pumping and 5% treatment and transmission during normal years; 91% SWP pumping and 9% treatment and transmission during dry years. Treatment and transmission: 9% solar and 91% PG&E.
6. 95% SWP pumping and 5% treatment and transmission. Treatment and transmission: 9% solar and 91% PG&E.
7. Only treated at DVWTP: 16% solar and 84% PG&E
8. 91% SWP pumping and 9% treatment and transmission. Treatment and transmission: 9% solar and 91% PG&E.